Canadian Stock Assessment
Proceedings Series 99/28

Évaluation des stocks canadien
Séries des comptes rendus 99/28

Report of the PSARC Pelagic Subcommittee Meeting August 31-September 2, 1999

M. Stocker and D. Radford(Editors)
Pacific Scientific Advice Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

September, 1999

Fisheries and Oceans Canada
Science

Pêches et Océans Canada
Sciences

Canada

102-01185/

Report of the PSARC Pelagic Subcommittee Meeting August 31-September 2, 1999

M. Stocker and D. Radford[1] (Editors)
Pacific Scientific Advice Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

September 1999

[1] Fisheries and Oceans Canada
555 West Hastings Street
Vancouver, B.C. V6B 4G3

PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 99-7
SEPTEMBER 1999

PELAGIC

CONTENTS PAGE

SUMMARY 2

INTRODUCTION 4

MANAGEMENT STRATEGY 5

CATCH TRENDS 7

STOCK STATUS AND FORECASTS FOR MAJOR ASSESSMENT REGIONS 9

STOCK ASSESSMENT WORKING PAPERS 20

P99-1 Stock assessments for British Columbia herring in 1999 and forecasts of the potential catch in 2000 20
P99-2 Age of sexual maturation and recruitment in Pacific herring 24
P99-3 Pacific herring tagging from 1936 to 1992: a re-evaluation of homing based on additional data 26
P99-4 Offshore herring distribution and 2000 recruitment forecast for the west coast of Vancouver Island stock assessment region 29
P99-5 An evaluation of inseason echo sounding estimates of herring biomass 30
P99-6 Natural mortality rate of adult herring (Clupea pallasi) from southern British Columbia 32
P99-7 An examination of age-specific exploitation of Pacific herring (Clupea pallasi) stocks from southern British Columbia by the roe fishery 35
Fishery Update 1998/1999 36

GENERAL SUBCOMMITTEE RECOMMENDATIONS FOR 1999 36

PROGRESS ON SUBCOMMITTEE RECOMMENDATIONS FOR 1998 37

PARTNERSHIPS WITH CLIENTS 40

APPENDIX 1 PSARC PELAGIC SUBCOMMITTEE MEETING AGENDA, AUGUST 31-SEPTEMBER 2, 1999 41
APPENDIX 2 PSARC PELAGIC WORKING PAPERS FOR 1999 43
APPENDIX 3 LIST OF PARTICIPANTS FOR AUGUST 31-SEPTEMBER 2, 1999 PSARC PELAGIC MEETING 44
APPENDIX 4 CRITERIA FOR ASSESSMENT OF STOCK STATUS IN 1999: QUEEN CHARLOTTE ISLANDS 45
APPENDIX 5 CRITERIA FOR ASSESSMENT OF STOCK STATUS IN 1999: PRINCE RUPERT DISTRICT 46
APPENDIX 6 CRITERIA FOR ASSESSMENT OF STOCK STATUS IN 1999: CENTRAL COAST 47
APPENDIX 7 CRITERIA FOR ASSESSMENT OF STOCK STATUS IN 1999: STRAIT OF GEORGIA 48
APPENDIX 8 CRITERIA FOR ASSESSMENT OF STOCK STATUS IN 1999: W.C VANCOUVER ISLAND 49

SUMMARY

The PSARC Pelagic Subcommittee met August 31-September 2, 1999 at the Best Western Bayside Inn in Parksville, B.C. The Subcommittee reviewed seven Working Papers and one Fishery Update. External participants from First Nations, fishing industry and Parks Canada attended the meeting.

Stock Status and Recommended Yield

The five major herring stocks in B.C. are managed by a fixed harvest rate policy in conjunction with a Cutoff level. Cutoff levels are set at 25 percent of unfished average biomass. Yield recommendations are set at 20 percent of forecast annual biomass unless the forecast is close to or below Cutoff levels. Assessments of major stocks are conducted using both age-structured (ASM) and escapement (ESM) models. For several years, divergence of results between the ASM and EM have been noted by the Subcommittee. In 1999, Herring staff examined the underlying assumptions of the age-structured model and submitted the ASM model to diagnostic tests to resolve the discrepancies between the two models. While substantial progress has been made there are still some unresolved issues that need further work.

For the five major stock assessment regions in B.C., the forecast biomass for 2000 is 205,340 tonnes. Application of the harvest rate policy results in a recommended yield of 39,470 tonnes for 2000.

Queen Charlotte Islands - The pre-fishery biomass forecast for 2000 at the 50% probability level is 15,080 tonnes (50% CI: 13,180-16,410 tonnes) assuming average recruitment. The forecast of 15,080 is above the Cutoff of 10,700 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 3,020 tonnes.

Prince Rupert District – Assuming average recruitment, the pre-fishery biomass forecast for 2000 at the 50% probability level is 37,000 tonnes (50% CI: 33,880-40,180 tonnes). The forecast of 37,000 is well above the Cutoff of 12,100 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 7,400 tonnes.

Central Coast - The pre-fishery biomass forecast for 2000 at the 50% probability level is 47,040 tonnes (50% CI: 44,510-53,460 tonnes) assuming average recruitment. The forecast of 47,040 is well above the Cutoff of 17,600 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 9,410 tonnes.

Strait of Georgia – The pre-fishery biomass forecast for 2000, assuming average recruitment, at the 50% probability level is 84,720 tonnes (50% CI: 70,170-94,950 tonnes). The forecast of 84,720 is well above the Cutoff of 21,200 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 16,940 tonnes.

West Coast Vancouver Island - The Subcommittee recommended poor-average recruitment for this stock in 2000. The prediction of poor-average recruitment is based on a long-term DFO research program which has demonstrated that herring recruitment tends to be poor when ocean temperatures are warm and the summer biomass of predators is high during the first year of life. The pre-fishery biomass forecast for 2000 at the 50% probability level is 21,500 tonnes (50% CI: 20,240-33,070 tonnes). The forecast of 21,500 is just above the Cutoff of 18,800 tonnes. Application of the harvest rule to the forecast resulted in a recommended yield of 2,700 tonnes (i.e. 21,500-Cutoff = 2,700 tonnes). The Subcommittee noted that there is a 38 percent probability that the spawning stock will be below the Cutoff after the harvest.

Minor Stocks - The Subcommittee recommended a yield of 57 tonnes for Area 27 computed as 10% of the assessed 1999 abundance, and no surplus in Area 2W.

Working Paper P99-1: Stock Assessment for British Columbia herring in 1999 and forecasts of the potential catch in 2000

The Subcommittee accepted the working paper subject to revisions. The Subcommittee recommended that a PSARC sponsored workshop be held in 2000 that will thoroughly examine input data, model parameterization, and the treatment of error variances in both assessment models.

Working Paper P99-2: Age of sexual maturation and recruitment in Pacific herring

The Subcommittee accepted the paper with revisions. The Subcommittee agreed with one reviewer who suggested that virtually all age 2+ herring are mature.

Working Paper P99-3: Pacific herring tagging from 1936 to 1992: a re-evaluation of homing based on additional data

The Subcommittee accepted the working paper subject to revisions. The Subcommittee does not recommend any changes to the stock assessment boundaries based on this paper. More work from other studies is required, and therefore it would be premature to adjust any boundaries at this time.

Working Paper P99-4: Offshore herring distribution and 2000 recruitment forecast for the west coast of Vancouver Island assessment region

The Subcommittee accepted the working paper, but deferred discussion regarding the recruitment forecast to the section of the meeting in which individual stock forecasts are determined for each stock region.

Working Paper P99-5: An evaluation of inseason echo sounding estimates of herring biomass

The Subcommittee accepted the working paper subject to revisions.

Working Paper P99-6: Natural mortality rate of adult herring (*Clupea pallasi*) from southern British Columbia

The Subcommittee accepted the working paper subject to revisions. The evidence that M increases with age is compelling and the Subcommittee recommended that the implications of this on the results of the catch age analysis be examined using simulation before the next assessment.

Working Paper P99-7: An examination of age-specific exploitation of Pacific herring (*Clupea pallasi*) stocks from southern British Columbia by the roe fishery

The Subcommittee decided that the amount of effort required to revise the paper was not warranted at this time, and therefore did not accept the paper. However, the Subcommittee felt that the topic was important and that it could be revisited in the future, following the recommendations and suggestions made by the reviewers.

The Subcommittee developed a series of recommendations for further work as a result of review of the working papers and Subcommittee discussion.

INTRODUCTION

The Subcommittee met on August 31 - September 2, 1999 at the Best Western Bayside Inn in Parksville, B.C. to review the status of herring stocks in 1999 and to forecast abundance and potential yield for 2000. The Chair of PSARC opened the meeting on behalf of the Subcommittee Chair, welcoming the participants. During the introductory remarks, the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda (Appendix 1). The Subcommittee reviewed seven working papers (Appendix 2), one fishery update and evaluated the impacts of pertinent assessment criteria (Appendices 4-8) in the formulation of advice to fisheries managers. The Subcommittee provided recommendations specific to the working papers in addition to general recommendations for further assessment work in support of management. Working paper titles, authors, and reviewers are listed in Appendix 2. A list of meeting participants is included as Appendix 3.

The Subcommittee evaluated a set of assessment indicators for each of the five major assessment regions. These criteria include:

- *Data quality*: catch data, spawn survey adequacy, consistency in age composition data;

- *Spawn and stock trends*: age-structured model and escapement model biomass estimates, spawn indices;
- *Perception of stock status*: based on charter skipper and district staff field observations;
- *Recruitment trends*: age-structured model estimates, auxiliary survey data;
- *Cutoff*: minimum spawning biomass level for stock conservation;
- *Forecast abundance (run size)*: for age-structured and escapement models, and evaluation of recruitment assumptions;
- *Additional information*: independent predictions of recruitment, size-at-age trends.

Subcommittee review of the assessment documents, in conjunction with the assessment criteria, was used to draw conclusions about the current biological status of the stocks and to provide yield recommendations for harvest in 2000. The following abbreviations are used throughout the Advisory Document:

ASM	Age-structured model
EM	Escapement model
CC	Central Coast
FSC	Food, Social, Ceremonial
HCRS	Herring Conservation Research Society
PR	Prince Rupert District
QCI	Queen Charlotte Islands
SG	Strait of Georgia
WCVI	West Coast Vancouver Island
CI	Confidence Interval

MANAGEMENT STRATEGY

Major Stocks

Five major British Columbia herring stocks are currently managed by a fixed harvest rate strategy in conjunction with a fishing threshold or "Cutoff" level. Recommended yields are set at 20 percent of the forecast biomass for each of the major assessment regions, provided that the recommended yield does not reduce the biomass below the Cutoff. The 20 percent harvest rate is considered to represent a conservative level of removals given the biological productivity of the major herring stocks. Cutoff levels are set at 25 percent of the estimated unfished average biomass, as determined by simulation analyses. As the forecast abundance approaches the Cutoff, the recommended yield is the difference between the forecast abundance and the Cutoff. When the forecast falls below the Cutoff, a decision may be made to close the fishery to rebuild the stock. The objective of a Cutoff is to prevent relatively large fishery removals on stocks at low levels of abundance. This harvest strategy has been in place since 1983, prior to which the fishery was managed through a fixed escapement policy. A recent review (PSARC Working Paper H95-02) concluded that "*... the current management policy provides an adequate*

level of protection to conserve the stocks from a fishery collapse, and generates high long-term yields."

A summary of the performance of the forecasting procedure for 1999 herring fisheries is shown in Table 1, which compares the 1998 forecast of abundance in each stock assessment region to observed biomass in 1999 based on spawn surveys, catch, and model estimates. Note that all numbers were rounded to the nearest 100 tonnes after the requisite calculations.

Table 1 Comparison of 1998 PSARC forecasts of 1999 herring abundance with estimates of 1999 observed biomass, catch, and escapement (tonnes). The recruitment assumption that generated the forecast biomass (poor, average, good) and the observed recruitment category are shown in brackets. All numbers rounded to the nearest 100 tonnes.

Management Region	1998 Forecast of 1999 Biomass	1999 Observed Biomass	1999 Validated Roe Catch	1999 Escapement
Queen Charlotte Islands	28,200 (average)	13,500 (poor)	3,000	9,700
Prince Rupert	24,400 (average)	28,800 (poor)	2,100	25,700
Central Coast	43,400 (average)	37,700 (poor)	7,500	28,900
Strait of Georgia	78,900 (average)	83,400 (poor-average)	11,800	70,200
West Coast Vancouver Island	39,600 (poor)	24,100 (poor)	4,400	18,800
Totals	214,500	187,500	28,800	153,300

Minor Stocks

There are small or "minor" herring stocks that exist outside the five major stock assessment regions. The minor stocks are assessed opportunistically due to their inaccessibility, so the data series is neither continuous nor extensive. In its 1993 report, the PSARC Herring Subcommittee advised that there is no basis for fishing minor stocks above the 20 percent harvest rate established for the major stocks, and that the

Department of Fisheries and Oceans should also protect a minimum spawning biomass for the minor stocks.

At the 1994 PSARC Herring meeting, the Subcommittee recommended that because of incomplete historic data, minor stock harvests should be based on the estimated biomass of spawners in the previous season. Consequently, the Subcommittee recommended that the maximum biomass of fish harvested should not exceed 10 percent of the estimated previous season biomass. The recommended harvest rate for minor stocks is more conservative than the rate adopted for the major stocks; it is intended to compensate for the fact that minor stock survival and recruitment levels cannot be reliably predicted. The data do not allow accurate estimation of minor stock Cutoff levels. The Subcommittee advised that the Department of Fisheries and Oceans should review biomass levels in light of available historic information prior to allocating minor stock harvests to clients. It noted that some minor stocks exhibit large fluctuations in abundance, therefore, the opportunity for harvest may not be available every year.

CATCH TRENDS

Herring in British Columbia waters have supported some form of commercial fishery since 1877. Reliable records of place, date, and quantity caught are available since 1950. A fishery for a dry salted market from 1904 to 1934 (with catches up to 85,000 tonnes annually) was followed by a reduction fishery (1935 to 1967). During the reduction, fishery catches were taken during the inshore spawning migrations from October to February. Very large catches (200,000 tonnes annually) in the early 1960s, in conjunction with a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery allowed a gradual recovery of stocks. The roe herring fishery began in 1972. Herring are now caught on or near the spawning grounds by both purse seines and gillnets.

In 1999, there were 241 seine licenses eligible to fish. Another 11 seine licenses were retired for the test fishing program. There were 1,258 gillnet licenses eligible to fish in 1999. This does not include 8 licenses retired for the test fishing program, 55 spawn on kelp trade-ins, and 5 AFS purchases. In 1999, all seine and gillnet fisheries were pooled. Total roe landings have averaged 28,100 tonnes from 1995 to 1999.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were provided. The PSARC recommended yield, actual quota in the roe fishery, and roe catches (thousands of tonnes) since 1983 are listed in Table 2.

Table 2 Stock biomass forecast, recommended yield, actual roe fishery quota, and roe catches (tonnes x 1000) since 1983.

		1983[e]	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999[d]
QCI[f]	Forecast[a]					15.3	12.1	13.7	35.3	23.2	18.1	17.7	12.4	7.7	6.7	11.0	19.8	28.2
	Rec. Yield[b]					2.2	0.0	2.7	7.1	4.6	3.6	3.5	1.0	0.0	0.0	0.3	4.0	5.6
	Roe Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3	3.0	0.0	0.0	0.0	0.0	1.6	3.0
	Roe Catch[c]	8.1	5.0	6.3	3.6	2.0	0.3	1.4	9.0	7.0	3.8	4.0	0.3	0.0	0.0	0.0	1.4	3.0
PR	Forecast[a]					32.1	43.8	42.6	23.3	19.4	30.5	55.1	34.1	21.9	21.2	36.1	34.0	24.4
	Rec. Yield[b]					6.4	8.7	8.5	4.7	3.9	6.1	11.0	6.8	4.4	4.2	7.2	6.8	4.9
	Roe Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2	5.4	4.9	2.3	2.4	5.5	5.5	2.0
	Roe Catch[c]	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.9	3.5	5.0	6.3	4.7	2.1	3.1	5.5	3.2	2.1
CC	Forecast[a]					23.0	23.8	48.5	43.2	38.2	37.7	70.1	69.8	54.4	25.8	20.7	44.5	43.4
	Rec. Yield[b]					4.6	4.8	9.7	8.6	7.6	7.5	14.0	14.0	10.9	5.2	3.1	8.9	8.7
	Roe Quota	*	6.6	4.1	2.3	3.3	3.7	7.8	7.4	6.2	5.3	7.8	10.3	8.5	3.2	1.4	7.8	6.9
	Roe Catch[c]	5.7	7.2	5.2	3.3	3.6	4.5	9.5	8.4	8.9	8.3	10.5	11.9	9.6	4.3	3.6	8.6	7.5
SG	Forecast[a]					53.0	46.7	49.4	55.2	69.8	59.2	91.8	97.4	69.5	63.4	77.2	72.7	78.9
	Rec. Yield[b]					10.6	9.3	9.9	11.0	14.0	11.8	18.3	19.5	13.9	12.7	15.5	14.5	15.8
	Roe Quota	11.7	11.6	4.7	0.0	8.0	6.4	7.4	7.1	9.1	9.7	11.0	14.4	11.9	10.8	13.2	13.0	11.5
	Roe Catch[c]	16.4	10.2	6.2	0.2	9.1	7.5	7.4	7.9	10.6	12.5	13.1	16.7	12.5	13.6	15.4	12.7	11.8
WCVI[g]	Forecast[a]					48.3	39.6	52.6	35.9	33.9	29.1	NA[h]	36.3	20.8	21.4	24.1	40.1	39.6
	Rec. Yield[b]					9.7	7.9	10.5	7.2	6.8	5.8	3.4[h]	7.3	2.0	2.0	4.8	8.0	7.9
	Roe Quota	4.5	4.5		0.0	9.4	8.1	10.3	7.2	6.7	2.9	2.7	5.0	1.3	0.9	3.7	7.5	5.1
	Roe Catch[c]	8.7	6.7	0.2	0.2	15.9	9.7	13.4	9.9	8.6	3.7	5.6	6.0	2.0	0.8	6.7	7.0	4.4
Coast	Forecast	0.0	0.0	0.0	0.0	171.7	166.0	206.8	192.9	184.5	174.6	234.7	250.0	174.3	138.5	169.1	211.1	214.5
	Rec. Yield	0.0	0.0	0.0	0.0	33.5	30.7	41.3	38.6	36.9	34.8	50.2	48.6	31.2	24.1	30.9	42.2	42.9
	Roe Quota	28.0	31.3	18.8	12.5	27.5	25.7	33.7	30.7	29.3	25.4	29.9	34.6	24.0	17.3	23.8	35.4	28.5
	Roe Catch	38.9	32.6	24.4	15.6	36.7	29.9	40.2	40.1	38.6	33.3	39.5	39.6	26.1	21.8	31.1	32.9	28.8

[a] PSARC stock forecast used to derive recommended yield;
[b] PSARC recommended yield, includes allocations to non-roe fisheries;
[c] Roe catch includes all test fishery catches;
[d] Catch in 1999 was the dockside validated catch;
[e] In 1983, the quota for North of Cape Caution was 11.8 tonnes;
[f] In 1983, 1985, 1990, 1991, 1992 and 1993 catch for QCI included both areas 2E and 2W;
[g] Includes Area 27 catch in 1983 & 1984 but excludes it in 1992, 1993, 1994, 1995 following removal from assessment regio
[h] No consensus on stock status, recommended that catch not exceed 1992 level.

STOCK STATUS AND FORECASTS FOR MAJOR ASSESSMENT REGIONS

Management Regions for Major Stocks

The stock assessment regions for major herring stocks are shown in Figure 1. For northern British Columbia, the stock assessment regions used for the 1999 assessments are the same as those used in previous years. In the Queen Charlotte Islands (QCI), the assessment region extends from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District (PR) stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast (CC) assessment region encompasses Area 7, Kitasu Bay in Area 6, and Kwakshua Channel in Area 8. As recommended by the Herring PSARC Subcommittee in 1991, the Strait of Georgia (SG) is considered a single stock complex which includes Deepwater Bay and Okisollo Channel in Area 13 and all of Areas 14 to 19, 28 and 29. In 1993, the northern (Area 25) and southern (Area 23/24) Statistical Areas were combined into the West Coast Vancouver Island (WCVI) assessment region.

Stock Assessment

Two analytical models, an age-structured model (ASM) and an escapement model (EM), are applied to each management region. At the direction of the Subcommittee the ASM was submitted to diagnostic tests with respect to the interaction of the natural mortality parameter with other model parameters. The assumption that the tuning index is proportional to stock biomass was also examined in 1999. After consideration of the in depth examination of the ASM, (see below) the Subcommittee decided to adopt the model forecast for 2000 that was most appropriate for a particular management region.

The potential recruitment of age 2+ fish to each stock is calculated for each model as the mean of the top one-third, middle one-third and bottom one-third of the recruitment estimates from the 1951 to 1999 time series. In the absence of additional information to forecast recruitment, the average recruitment forecast is used. Recruitment is added to the expected age 3+ and older abundance to obtain the forecast abundance. The recommended yield is 20 percent of the forecast abundance. If this yield would reduce the escapement biomass of a stock below the Cutoff, the recommended yield is calculated from the following equation:

$$\text{Yield} = \text{Forecast} - \text{Cutoff}$$

Thus, progressively smaller fisheries are recommended when a stock approaches its Cutoff level. The Cutoff is calculated independently for each stock assessment region.

An example of yield calculations for three levels of forecast biomass is shown in Figure 2. The Cutoff for this example is set at 10,000 tonnes (dashed vertical lines). The upper panel shows catch (tonnes) as a function of the forecast biomass, while the lower panel shows harvest rate as a function of the forecast biomass. There are three scenarios denoted by A, B, and C on the figure panels:

(A) The forecast biomass of 7,500 tonnes is below the Cutoff, so the recommended yield is 0, and the harvest rate is 0.

(B) If the 20 percent harvest rate was applied, the forecast biomass of 11,000 tonnes would yield 0.2*11,000=2,200 tonnes. However, this yield would bring the stock size below the Cutoff value to 11,000-2,200=8,800 tonnes. Thus, the recommended yield is 11,000-10,000=1,000 tonnes. This is equivalent to a harvest rate of 1,000/11,000=0.09, a value roughly half that of the rate of 0.2 used at higher levels of biomass.

(C) The forecast biomass of 20,000 tonnes is well above the Cutoff, so the recommended yield is 0.2*20,000=4,000 tonnes.

Recommended Coast-Wide Yield for 2000

The recruitment assumption, corresponding 2000 pre-fishery biomass forecast, and the recommended yield for each of the major stock regions are listed in Table 3. The spawning stock biomass trends based on the age-structured model (ASM) and escapement model (EM) are shown in Figure 3 and Figure 4. These trends were interpreted in light of the assessment criteria listed in Appendices 4-8 for each management region to determine the recommended yield. Regional synopses are provided below. The Subcommittee noted that the total recommended yield of approximately 39,470 tonnes for 2000 is an 8 percent decrease from the total recommended yield of 42,910 tonnes in 1999.

Table 3 Recommended Yield in 2000 for Major Herring Stocks

Assessment Region	Cutoff Biomass (tonnes)	Recruitment Assumption	Forecast Biomass (tonnes)	Recommended Yield (tonnes)
Queen Charlotte Islands	10,700	Average	15,080	3,020
Prince Rupert District	12,100	Average	37,000	7,400
Central Coast	17,600	Average	47,040	9,410
Strait of Georgia	21,200	Average	84,720	16,940
West Coast Vancouver Island	18,800	Poor-Average	21,500	2,700
Total			205,340	39,470

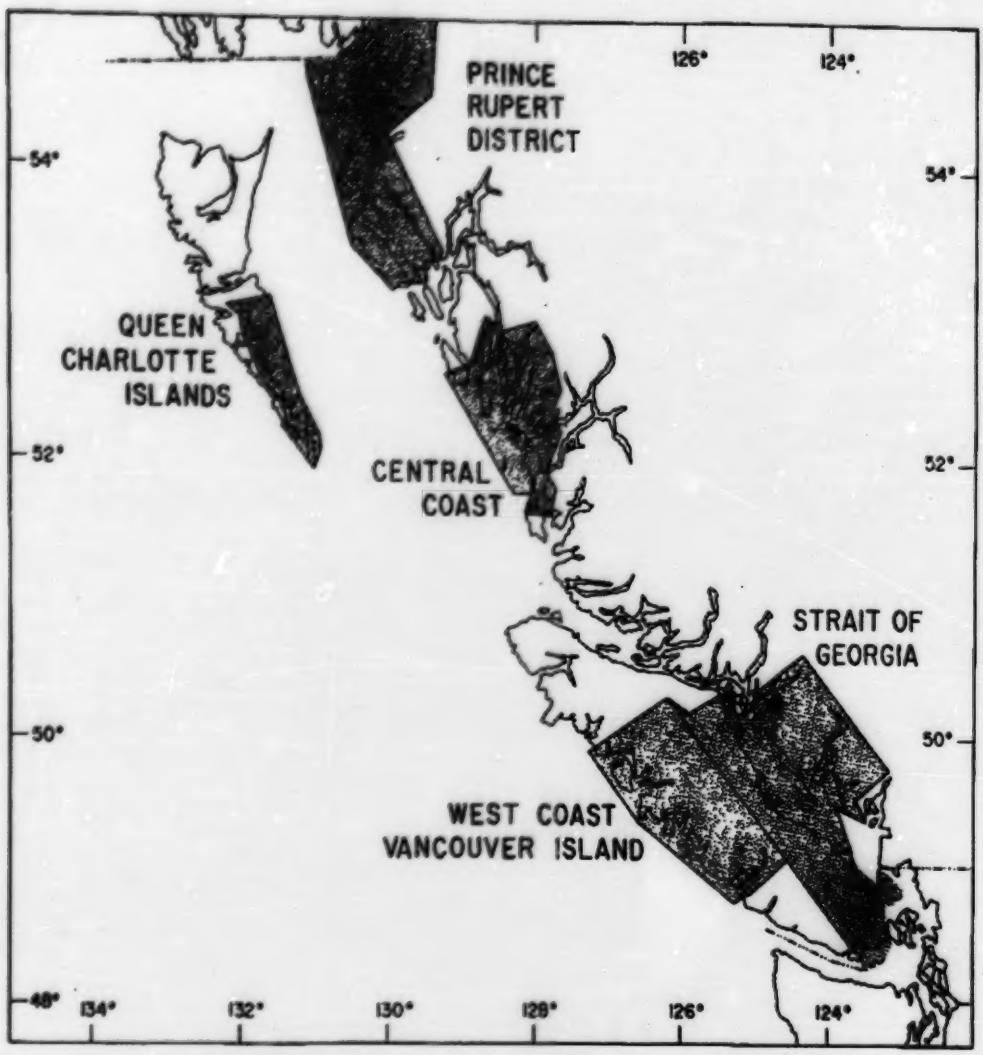


Figure 1. Herring stock assessment regions in British Columbia.

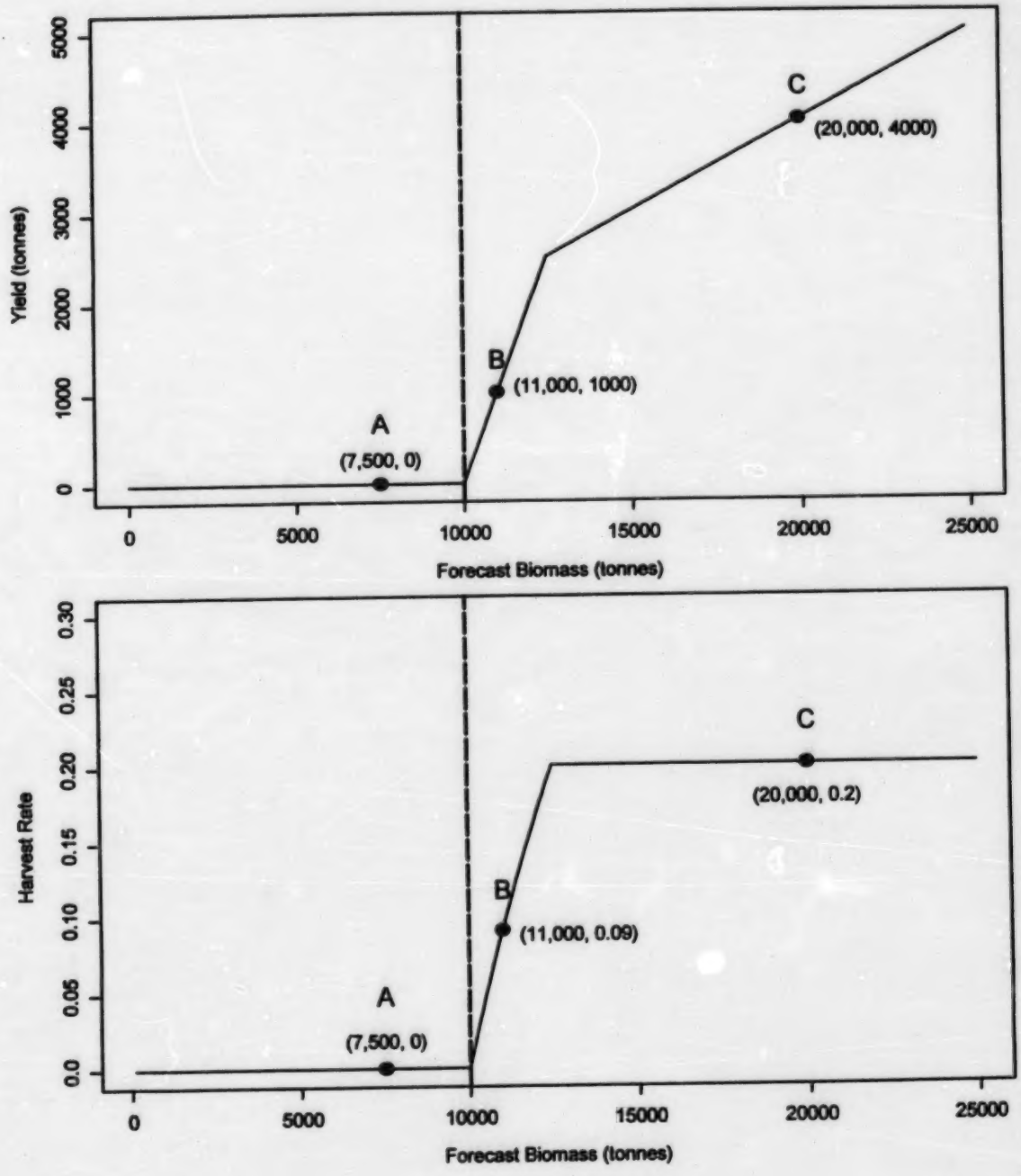


Figure 2. Examples of yield and harvest rate at three different levels of forecast biomass. The letters A, B, and C denote three harvest scenarios as described in the text.

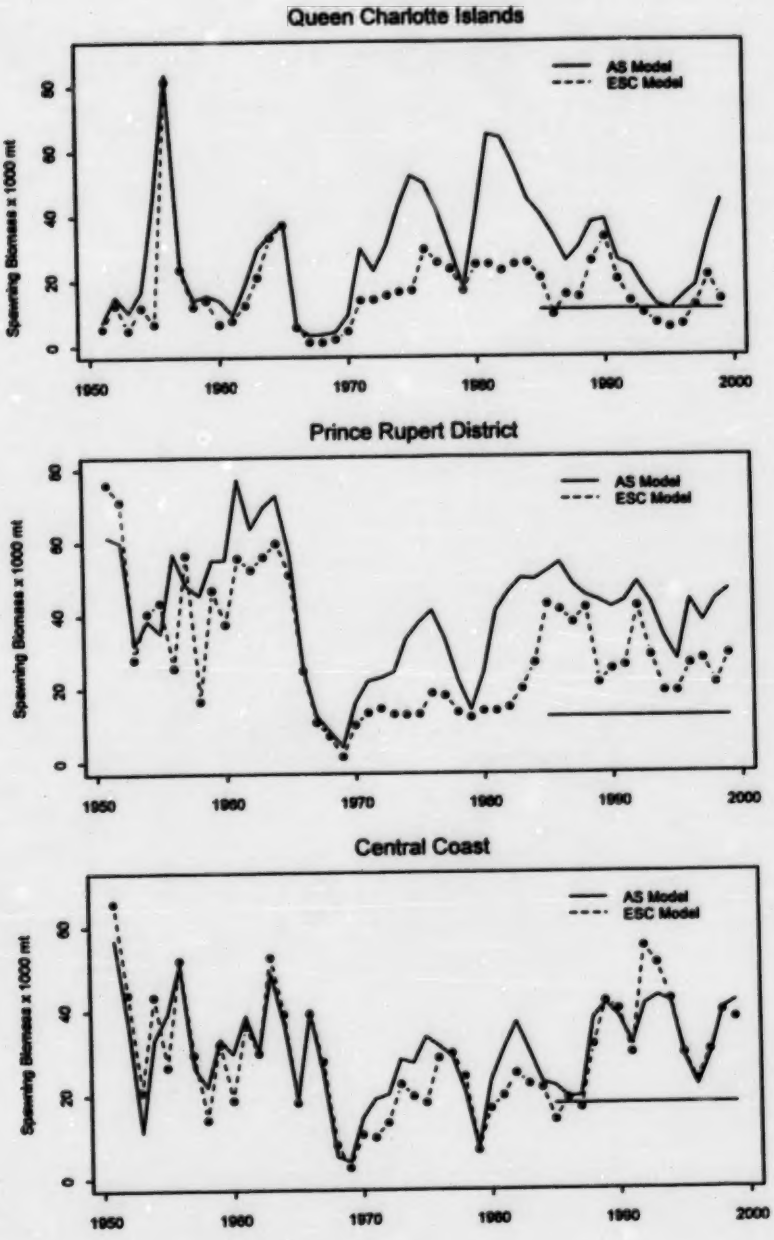


Figure 3. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1951-1999. Horizontal line indicates the Cutoff level for each stock.

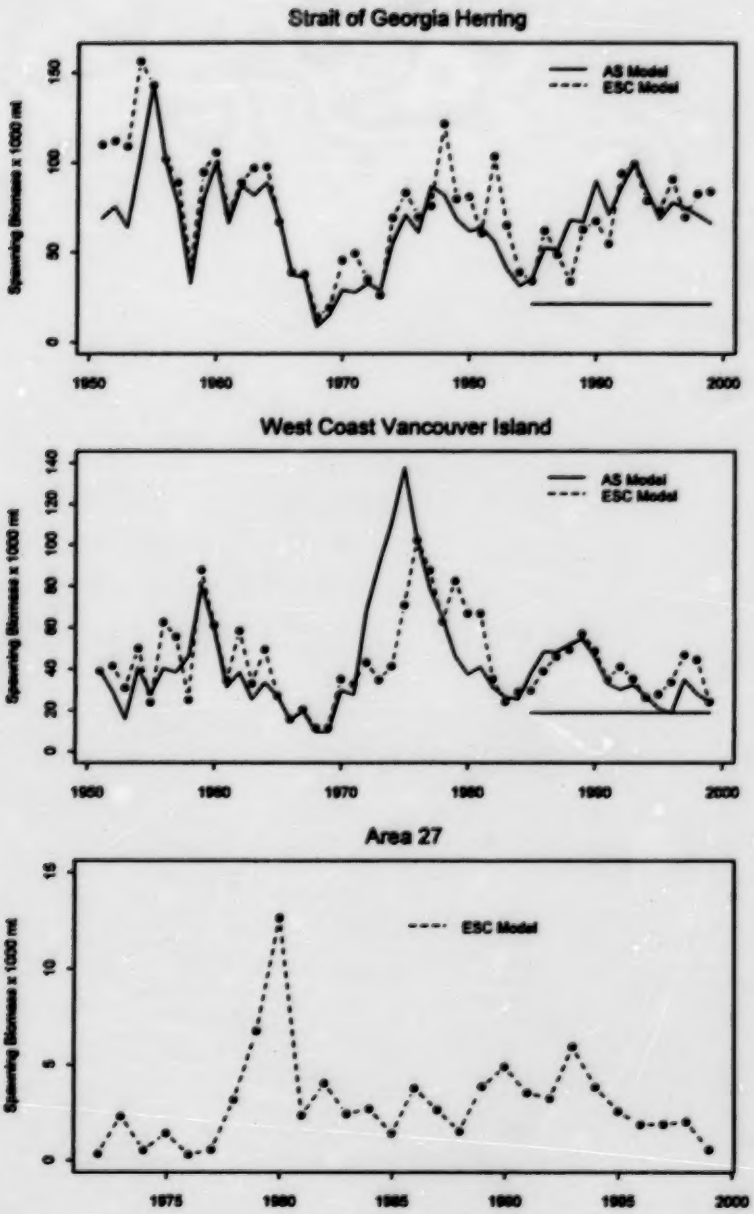


Figure 4. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions and Area 27, 1951-1999. Horizontal line indicates the Cutoff level for each stock.

Queen Charlotte Islands

Background

Landings during the reduction fishery period (1951 to 1968) were highly variable, targeting on a few strong year classes. The maximum catch taken during this period was over 77,000 tonnes however, there were 6 years when catches were less than 1,000 tonnes. Catches have been more stable since the beginning of the roe fishery and have generally been in the range of 4,000 to 8,000 tonnes. The area was closed to roe herring fisheries in 1988 due to stock concerns. The stock recovered after the closure but declined from 1990 to 1995. In response to the observed decline, annual roe fishery catches were reduced from 7,800 tonnes in 1990 to 2,700 tonnes in 1993. In 1994, the forecast return was close to Cutoff, and fishing was restricted to Food, Social and Ceremonial (FSC) harvest and spawn-on-kelp only. For 1995 and 1996, the forecast abundance was below Cutoff so fishing was limited to FSC harvest only. In 1997, FSC harvest was permitted, and three spawn and kelp operators used a maximum of 150 tonnes of herring to obtain their quota. The roe fishery was re-opened in 1998, with a harvest of 1,400 tonnes. In 1999, the roe harvest was 3,000 tonnes.

Assessment Criteria

The FSC catch reporting from the Queen Charlotte Islands in 1999 is incomplete. In-season stock sampling and spawn assessment programs were carried out in a manner consistent with other assessment areas, with the exception of Eggar's Bay which was not surveyed. Biological samples were obtained from all fisheries.

The age-structured model shows an increasing trend in spawning biomass since 1995. The escapement model shows a 49 percent decrease in the spawning biomass from 1998-99. The declining stock trend observed between 1990 and 1995 resulted from a series of years with poor recruitment. Increase in biomass since 1995 resulted from greater than average recruitment of the 1993 and 1994 year classes. The 1996 year class appears to be poor.

Although the EM is believed to produce conservative forecasts, the Subcommittee considered the results of the ASM to be unlikely. The Subcommittee adopted the escapement model assuming the average recruitment scenario. The pre-fishery biomass forecast for 2000 at the 50% probability level (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 15,080 tonnes (50% CI: 13,180-16,410 tonnes). The forecast of 15,080 is above the Cutoff of 10,700 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 3,020 tonnes.

Prince Rupert

Background

During the period of the reduction fisheries, herring catches in the Prince Rupert District were generally in the range of 10,000 to 50,000 tonnes annually. Since the beginning of the roe herring fishery, catches have averaged 5,000 tonnes and have not exceeded 9,000 tonnes. Since 1972, the fishery was closed only in 1983. The area has supported substantial roe herring and spawn-on-kelp fisheries in recent years. However, there was no seine fishery carried out in the traditional location (Kitkatla Inlet) from 1996 to 1999 due to the low biomass of spawners in recent years. A shift in the spawn pattern was observed in 1999. There was more spawning in the Venn Passage area.

Assessment Criteria

There was no FSC catch reported from this area in 1999. The quality of assessment data in 1999 was adequate. The trend in spawn from the ASM and EM agree. Comments from fishery managers and charter skippers in 1999 indicate that stock status has improved in this area.

Estimates of the 1999 stock abundance for the Prince Rupert District assessment region are more consistent for the two models than in recent assessments. Both models indicated an increase in abundance in 1999. The declining stock trend observed between 1990 and 1995 resulted from a series of years with poor recruitment. Increase in biomass since 1995 resulted from greater than average recruitment of the 1994 and 1993 year classes. These year classes represent 20 and 25 percent of the run. The dominant 1995 year class comprises 43 percent of the stock.

Given the history of overestimation of the ASM, the Subcommittee recommended to adopt the EM for forecasting biomass in 2000. In the absence of additional information, the Subcommittee adopted an average recruitment scenario. The pre-fishery biomass forecast for 2000 at the 50% probability level (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 37,000 tonnes (50% CI: 33,880-40,180 tonnes). The forecast of 37,000 is well above the Cutoff of 12,100 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 7,400 tonnes.

Central Coast

Background

Landings during the reduction fishery period (1950-1968) ranged to just over 44,000 tonnes and were generally around 10,000 to 35,000 tonnes. During the subsequent roe fishery period (1972 to present), landings have averaged 7,145 tonnes and reached a maximum of 14,000 tonnes in 1978. No harvest was permitted in the Central Coast in 1979, but fisheries have occurred annually since that time. Harvests were approximately 10,000 tonnes from 1993 to 1995, then were reduced to 3,200 tonnes in 1996 in

response to declining abundance. Abundance has increased dramatically over the past three years as a result of improved recruitment.

Assessment Criteria

Abundance trends provided by the two assessment models agreed closely and indicated a recent increase in stock abundance from the recent low in 1996. A good recruitment to the stock occurred in 1997 (1994 year class), following four years of poor to average recruitment. The predominant 1995 year class of age 3+ fish comprises 43 percent of the stock, while the 1994 year class accounted for 34 percent of the spawning run. The 1996 year class accounted for 9 percent of the run.

The quality of assessment data collected in 1999 is considered to be good, however, FSC catch remains unreported from the Central Coast region. The use of dive spawn surveys has been expanded to cover all spawns in the assessment area. The spawn indices are high. Charter skippers perceived a shift of fish to the south resulting in an increase in biomass in southern areas such as Stryker Bay. Local management staff concluded stocks were healthy with spawning occurring in more areas than in recent years. A shift of spawn to areas outside of the usual seine fishing areas was observed.

In the absence of additional information, the Subcommittee adopted an average recruitment assumption in forecasting the CC stock in 2000. The Subcommittee noted that the retrospective analysis suggests the ASM tends to over-forecast abundance, and noted the potential for sampling bias in northern regions. The estimated natural mortality was very low relative to the other assessment regions at 0.28. Given the inconsistencies with the ASM the Subcommittee adopted the EM for the 2000 forecast. The pre-fishery biomass forecast for 2000 at the 50% probability level (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 47,040 tonnes (50% CI: 44,510-53,460 tonnes). The forecast of 47,040 is well above the Cutoff of 17,600 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 9,410 tonnes.

Strait of Georgia

Background

Annual herring landings from the Strait of Georgia during the reduction fishery period (1951 to 1968) were less variable than from other areas of the coast. With the exception of the 1952/53 season when industry disputes curtailed the herring fishery, and the 1967/68 season when stocks had collapsed, landings ranged from 31,000 tonnes (1966/67) to 72,000 tonnes (1955/56). During the period of roe herring fisheries, catches have averaged 11,600 tonnes. The area was closed to roe herring fishing in 1986, after which time harvests have increased to a peak of 16,304 tonnes in 1997 and a catch of 13,604 tonnes in 1998. The high catches in the 1990s have been supported by near record high stock abundance in the Strait of Georgia.

Assessment Criteria

All catch has been reported for the SG. All major spawns were surveyed in 1999. The early spawn in Nanoose Bay was not surveyed. Charter skippers commented that stocks looked good, although perhaps not as strong as in 1998. Management staff commented that spawning looked good, and comparable to previous years. Stock status looked comparable to the previous few years, although soundings were hampered by poor weather.

The ASM indicated a decrease in abundance in 1999, while the EM indicated no trend. The 1995 year class is predominant, contributing 41 percent of stock biomass while the 1994 year class constituted 19 percent of the run. The recruiting 1996 year class contributed another 25 percent to the total run size in 1999.

In the absence of additional information, the Subcommittee adopted an average recruitment assumption in forecasting the SG stock in 2000. The Subcommittee noted that the retrospective analysis results were mixed for this assessment region. The potential for sampling bias was not judged to be significant for the SG. The estimated natural mortality was high at 0.59. The Subcommittee adopted the escapement model assuming the average recruitment scenario. The pre-fishery biomass forecast for 2000 at the 50% probability level (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 84,720 tonnes (50% CI: 70,170-94,950 tonnes). The forecast of 84,720 is well above the Cutoff of 21,200 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a recommended yield of 16,940 tonnes.

West Coast Vancouver Island

Background

During the period of the reduction fishery, catches from the west coast of Vancouver Island reached nearly 70,000 tonnes in the 1958/59 season. In general, catches were in the range of 10,000 to 25,000 tonnes. During this period, annual harvests in the southern region (Area 23/24) exceeded harvests in the north (Area 25) for all but three years (51/52, 59/60, 62/63), often by large amounts. Since the roe fishery began in 1972, catches have been below the earlier levels, except from 1975 to 1978, when they ranged from 26,000 to 39,000 tonnes. In 1985 and 1986, the commercial fishery was closed along the entire west coast of Vancouver Island due to serious stock concerns. The stock subsequently rebuilt and the 1987 harvest of nearly 16,000 tonnes was the largest since 1979. However, the stock has experienced a declining trend since 1989; catches have averaged 5,400 tonnes since 1990 compared to an average harvest of 22,200 tonnes prior to 1980. Effort was restricted in 1995 and 1996 since forecast abundance was marginally above Cutoff in both years. In 1997, the forecast abundance was well above the Cutoff, and no effort restrictions were applied. The stock has shown a declining trend since 1997.

Assessment Criteria

Stock trends derived from the two assessment models indicated a decline to a low stock level from a recent peak in 1997. The decline resulted from a series of years with poor recruitment, interrupted by only one year of above average recruitment in the last eight years prior to 1997. Poor recruitment was observed in 1998 as predicted (H98-4). The 1994 and 1995 year classes account for 39 and 24 percent of the stock, respectively.

The quality of assessment sampling and data collected was good in 1999, although FSC catch reports are incomplete. Hesquiat Harbour spawn surveys were incomplete, and Barkley Sound deep spawn was not completely surveyed. Charter skippers commented that fish were very hard to estimate because of weather, and because they were on the bottom much of the time. Local management staff thought that stocks were considerably weaker in Barkley Sound.

In developing the forecast for 2000, a recruitment forecast presented in P99-4 predicted poor-average in 2000 (1997 year class). This prediction is based on two pieces of evidence: (1) an offshore trawl survey estimated that age 2+ herring (recruiting in 2000) will comprise about 43 percent of the spawning stock in 2000, as compared to an estimated 14 percent in 1999; and (2) an analysis of ocean temperatures and predator biomass (risk factor). Retrospective analysis of ocean temperature and predator biomass indicated that there is a 60 percent chance that the 1997 year class will be poor and a 40 percent chance that it will be average. Both the offshore survey and risk factor forecasts suggest that the 1997 year-class is likely to be poor-average in strength.

The Subcommittee noted that the retrospective analysis suggests the ASM tends to under-forecast abundance, although performance was improved in recent years. The estimated natural mortality of 0.45 was credible. Because the size of the projected spawning stock is not far above Cutoff, the Subcommittee adopted the precautionary action using the ASM assuming a poor-average recruitment scenario. The pre-fishery biomass forecast for 2000 at the 50% probability level (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 21,500 tonnes (50% CI: 20,240-33,070 tonnes). The forecast of 21,500 is just above the Cutoff of 18,800 tonnes. Application of the harvest rule to the forecast resulted in a recommended yield of 2,700 tonnes (i.e. 21,500-Cutoff = 2,700 tonnes). The Subcommittee noted that there is a 38 percent probability that the spawning stock will be below the Cutoff after the harvest.

Minor Stocks

The recommended yield for Area 27 is 57 tonnes, computed as 10 percent of the assessed 1999 abundance of 570 tonnes from the escapement model. No fishery is recommended in Area 2W due to the paucity of historical and recent spawn data, biological sampling for ages, and acoustic soundings from the area. There are no dominant age classes in recent biological samples for Area 2W.

STOCK ASSESSMENT WORKING PAPERS

This section presents a summary of working papers and corresponding reviews. Subcommittee discussion is recorded, along with recommendations for revision of each working paper and directions for future analyses. General recommendations from the Subcommittee appear later in the report.

P99-1 Stock assessments for British Columbia herring in 1999 and forecasts of the potential catch in 2000.

J. Schweigert and C. Fort ** Accepted with revisions **

Summary

Herring stock abundance in British Columbia waters was assessed for 1999 and forecasts were made for 2000 using two analytical methods: (1) escapement model; and (2) age-structured model. These models have been applied to assess herring abundance since 1984 and no significant changes were implemented in either model in conducting the current assessment. All available biological data on total harvest, spawn deposition, and age and size composition of the spawning runs were used to determine current abundance levels. No significant problems were evident in the extent and comprehensiveness of the data collections. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 1999 was 222,000 tonnes based on the age-structured model. This represents a 4 percent increase from 1998 abundance levels. This slight increase reflects the recruitment of a poor 1996 year-class in 1999 in most areas of the coast.

Forecasts of the pre-fishery spawning stock biomass in 2000 are presented for both models. Stock forecasts for the northern stock assessment regions are 120,000 and 83,000 tonnes for the southern regions assuming average recruitment to all areas.

The estimated harvestable surplus in 2000 (20 percent of the 2000 forecast herring run) is 40,500 tonnes for the entire B.C. coast assuming average recruitment to all areas. However, since consensus on stock levels for each assessment region may change as a result of PSARC review of these data, forecast run sizes, and harvestable surpluses, are subject to change.

Reviewers' Comments

This paper reviews the basic information used in the assessment, namely stock definitions, estimates of age composition of commercial catches, and especially the egg surveys that index the abundance of spawners. Two predictive models are presented: the "escapement model" and a conventional age-structured model. The escapement model is a purely empirical forecast of next year's abundance based on this year's abundance and the ratio of this year's abundance to last year's abundance at each age. (This ratio is called an "apparent survival rate" but as the authors point out, it incorporates

a number of factors in addition to ordinary survival.) The age-structured model is a standard, state-of-the-art piece of work, meaning that the authors have built a simulation model of the stock and the fishery (in this case three serial fisheries) and fitted it to the basic data to estimate year class strengths and other parameters. The parameterization of the model and the treatment of error variances are straightforward and sensible. Residuals about the model fits are well reported and well behaved. Toward the end of the paper the base model is compared with other parameterizations and a simple VPA, and the retrospective behavior of the base model estimates is presented. The reviewer concluded that this is clearly a competent and very thorough assessment.

The reviewer questioned assigning fixed variances to the estimates of total catch and egg abundance (4% and 18%) in the ASM. He had no argument with fixing the variances but in view of their strong influence on the estimates it would be helpful to have an explanation of why those values were chosen.

The escapement model is much less satisfactory in that the method provides no estimate of the variances of the biomass projections, but it appears from Fig. 2.1 that they must be large. This deficiency could perhaps be cured (i.e. by modeling the "apparent survival rates" as random walks, or smoothing, or filtering) but the reviewer recommended dropping this method rather than trying to develop variance estimates. The reviewer believed that the age-structured model makes better use of all the data, provides the flexibility needed to model all important aspects of the fishery, and allows for diagnostics that are much more informative about both the fishery and the model fit itself.

The authors report two sets of estimates of harvestable surplus based on the two models and do not recommend one or the other. In some areas, the numbers are quite different. The choice between the models is a purely technical matter, and the reviewer suggests that it is the assessment scientist's job to make a technical judgment and go on to recommend a single set of numbers to the managers. Even if PSARC is going to do that for herring, the reviewer felt that the authors should decide on a proposed recommendation and state their rationale for it in the paper. In this case, the age-structured model seems to be far superior to the escapement model that there should be no difficulty in making a choice.

On a minor point, the authors report two values for the projected mature biomass estimated with the age-structured model. One corresponds to the mode of the likelihood for the parameter vector, and the other corresponds to the mode of the marginal distribution ("likelihood profile") of the projected biomass, which is a derived quantity. This is sure to baffle anyone outside the profession. As is usual, the numbers are almost the same, and either set of values could be chosen and justified, but it confuses the issue to present both sets of numbers and not state which ones are the point estimates.

The reviewer noted, as the paper states, the significant retrospective patterns shown by the model results for Prince Rupert and the west coast of Vancouver Island should be investigated further.

Subcommittee Discussion

Last year the Subcommittee recommended that the ASM be submitted to diagnostic tests with respect to the interaction of the natural mortality parameter with other model parameters. The Subcommittee also suggested that the assumption that the tuning index is proportional to stock biomass requires validation through the use of a Virtual Population Analysis (VPA). The Subcommittee noted that the authors have addressed these issues in P99-1, and commends their effort. The Subcommittee thoroughly examined the ASM working through a checklist for stock assessment. The following highlights the discussion that took place while working through the stock assessment checklist.

Are data adequately presented and are they accepted? - The Subcommittee noted that there is no report on food and ceremonial catch from PRD, QCI and CC for 1999. The issue of fishery induced mortality was raised. This has been investigated in the past and it was found that GN drop out rates were 10 percent and kill rates were 1 percent. However, these studies did not address sub-lethal effects. The Subcommittee expressed concern about fishery-induced mortality. The Subcommittee noted that the catch-at-age data are not presented in P99-1. The Subcommittee recommended that the assessments include the catch-at age data.

Indices of abundance – All major herring spawns were surveyed in 1999. However, some deep spawning was missed in Barkley Sound. The Subcommittee noted that there are concerns about the completeness of surveying spawn in this area. The ASM assumes that the spawn index is proportional to the spawn deposition. This was tested using a VPA. The Subcommittee noted that the relationship seems nonlinear for the WCVI and QCI stocks. The spawning index is treated as an absolute estimate of spawn (q=1) in the EM and therefore is assumed to be directly proportional to the spawning population. This assumption is valid for low and medium stock levels, where concerns about conservation are important.

Age size and sex structure information – The Subcommittee noted that the pre-fishery and catch sampling data (Appendix 3.2) showed an increase in proportion of age 2+ in 9/27 instances in the PRD. This could results in biased parameter estimates of partial recruitment. The Subcommittee noted that size-at-age is not an issue for the forecast because last year's weight at age was used rather than a forecasted value. However, the Subcommittee questioned if weight-at-age changes are affecting overall stock productivity and would have implications for the Cutoff. The Subcommittee noted that relative fecundity remains constant because the egg size increases with female size.

Tagging data – Tagging data are not used in the current assessment. The Subcommittee noted that the suggestion of episodic migration (P99-3) may help with some model fitting. The current HCRS funded tagging experiments are addressing the stock concept question. The Subcommittee recommended that documentation of movement of biomass be demonstrated scientifically, and then incorporate these results into the assessment models. Incorporating movement from tagging data may improve ASM fit in the northern

stock areas. This research is currently funded by the HCRS and the first of a series of papers describing migration patterns should be available for the 2000 PSARC meeting.

Environmental data – The only stock for which environmental data are considered for recruitment forecasting is the WCVI stock. Recruitment/environment relationships for other areas are unclear and not useful for stock assessment. The Subcommittee noted that the 97 El Nino is the major event of the century and may have effects on some of the other stocks. Work on environmental effects on recruitment is underway for other stocks.

Fishery information - Information from test fishing skippers and DFO managers are included in the assessment process (Appendix 4-8).

Assessment model discussion – There was considerable discussion of the variable, and often high, natural mortality estimates indicated by the ASM. It was noted that the variable estimates of M might be more a function of different vulnerability schedules, migration of herring stocks , or sampling biases. The Subcommittee accepted variation of age-specific M estimated from the ASM. However, Central Coast estimates of M are still very low (0.279). A systematic examination of model parameters was conducted (Table 6.1). Table 6.1 shows how the ASM performed with differing estimates for M. The Subcommittee was concerned about the sensitivity of the biomass estimates produced by the ASM.

Catchability – The Subcommittee noted that slope of the spawn index/spawning escapement is non-linear in some stocks. This suggests that the spawn index is not directly proportional to the true biomass under some conditions. The violation of this assumption is of concern and should be investigated further. However, this situation should not affect the 1999 assessment.

Recruitment – There is no relationship between stock-recruitment assumed in the ASM. The ASM recruit time series is separated into thirds for poor, average and good recruitment. New research using neural network work techniques suggests a promising new method which can be used to forecast recruitment. The Subcommittee recommended that this approach be examined for the other areas on the coast.

Statistical formulation – The statistical formulation of the ASM is state of the art.

Evaluation of uncertainty – Uncertainty is currently not evaluated in the EM. Variance estimates can be generated for some parameters, and bootstrapping is potentially possible. Uncertainty is expressed by the ASM.

Even though the reviewer suggested dropping the EM, the Subcommittee felt that it was inadvisable to dismiss the EM at this time.

The Subcommittee concluded that the ASM is acceptable as a stock assessment tool for B.C. herring. However, the Subcommittee still had some concerns with respect to the interaction of the natural mortality parameter with other parameters. The Subcommittee

recommended that the merits of each model should be considered on a stock by stock basis.

Working Paper Recommendations

1) The Subcommittee accepted the working paper subject to revisions.
2) The Subcommittee recommended that a PSARC sponsored workshop be held in 2000 that will thoroughly examine input data, model parameterization, and the treatment of error variances in both assessment models.

P99-2 Age of sexual maturation and recruitment in Pacific herring

D.E. Hay and P.B. McCarter ** Accepted with revisions**

Summary

Catch curves from the commercial herring roe fishery in northern B.C. indicate that herring are fully recruited at age 4: in general, there are more age 4 fish in the catch than age 3 or age 5, and older ages. Catch curves are taken as evidence that in most assessment areas, a substantial part of the age 3 cohort is immature and not fully recruited to the spawning population. This is represented in the annual B.C. herring assessments in an age-structured model as the age-specific parameter lambda (λ) that represents the age-specific vulnerability to fishing gear.

There is, however, other evidence that most age 3 fish are sexually maturing. We present 3 types of evidence. (1) Ovarian histology: analyses of maturing ovaries taken from samples collected from several years and areas in the winter months indicates that virtually all age 3 females had vitellogenic oocytes, a condition found only in sexually maturing females. (2) Gonad weights: since 1982, gonads have been weighed as part of the routine herring sample analyses. When ovary weights exceed 5 percent of total body weight (defined as a gonosomatic index or 'GSI' > 5) sexual maturation has started. We then show that virtually all age 3 fish collected in the late winter and spring have a GSI of 5, or greater. (3) The Hjort Maturity scale: this index is recorded for all fish, but the results have not been presented in previous analyses. Using this scale, any fish with a Hjort index of 4 or greater is sexually mature. All age 3 herring, collected in the late winter or later, have a Hjort Index of 4 or more. Therefore, there is an apparent contradiction between the area-specific catch curves, which indicate incomplete recruitment of age 3 herring, and the observation that most age 3 are maturing.

There are two mutually exclusive hypotheses to explain this contradiction (1) the 'age-3 immature hypothesis' and (2) the 'sample bias' hypothesis. The present stock assessment models assume the 'age-3 immature hypothesis' - that there are many immature age-3 herring that do not reside with the main herring stock and are not available for capture. The alternative 'sample bias' assumes that most age 3 fish are mature, but their frequency in the samples of catches is under-represented. There is no

direct evidence to support the 'age-3 immature hypothesis'. If such evidence existed, it would consist of samples that consist mainly of sexually immature age-3 fish.

In the authors' reviews of the historical biological sampling data, we have not found such samples. Such fish have not been encountered during winter surveys of herring. On the other hand, there is evidence that samples from fishery catches may not be fully representative of the spawning populations. There are differences in the mean age of spawning fish when compared among different 'Statistical Areas', within each of the 'stock assessment areas'. In some areas and years, the duration of the sampling period often is shorter than the duration of the spawning period. Younger fish tend to spawn later so could be under-represented in samples. Therefore, there are data to support the 'sample bias' hypothesis.

In general, however, the authors conclude that the potential for sample bias may not fully explain the differences between the catch curves and observed age at maturity. They suggest a new hypothesis: that there are episodic migrations of younger but mature herring from southern to northern areas. The consequence is that the observed catch curves are valid, because the older age groups are augmented from southern mature migrants, not late maturing fish. This migration hypothesis concurs with a recent review and analyses of tagging data and would support the general validity both of the catch curves and our observations about the age of sexual maturation. Of the competing hypotheses on this issue, the hypothesis of episodic migrations is the most parsimonious and precautionary.

Reviewers' Comments

Both reviewers found no dispute with the author's contention that age 2+ herring may be mature. Reviewer A expressed concern about the manner in which the ASM models a pool of unavailable age 2+ fish. Reviewer B also discussed the linkage between the author's findings and the ASM, but could not assess the author's hypothesis of episodic migrations of age 2+ fish from the southern areas to northern ones.

Reviewer A did support the episodic drift hypothesis and used this to support a further critique of the ASM and its assumptions. He also focussed on the question of whether the available sampling data provided an accurate estimate of λ.

Reviewer A felt that the authors presented some plausible alternatives to some of the assumptions of the ASM and proposed a series of additional analyses to test these.

Both reviewers also provided a considerable number of editorial comments.

Subcommittee Discussion

The Subcommittee discussed the general conclusion that the majority of age 2+ herring examined were mature. The Subcommittee generally concurred with the results of this study, and with the concerns raised by the two reviewers. Three major issues were

discussed. First, there is an important and unresolved question regarding the potential sampling bias associated with the data used in the analysis. The present study primarily used herring that were collected on the spawning grounds. The Subcommittee questioned why immature herring would be expected on the spawning grounds, and noted that in some years, sampling was completed before major spawning occurred. There is a possibility that age 2+ were under-represented in the samples, and it was suggested that there is a need to do additional sampling throughout the spawning run.

Second, the Subcommittee discussed concerns about the discrepancy in the interpretation of λ used in the herring age-structured model. Results from this study suggest that λ, if an estimate of age specific maturity, is probably not adequately estimated from sampling data. The Subcommittee suggested holding a workshop with herring biologists and invited experts to evaluate parameters used in the age-structured model (i.e., mortality). It was noted that structural modifications of the age-structured model is non-trivial, and concern was expressed that tinkering was potentially an endless activity.

Third, the Subcommittee noted that a key biological question regarding the maturity schedule of herring still needs answering. It was suggested that funding be secured to collect herring from the north coast areas in late fall/early winter, and to redo the GSI analysis to determine if age 2+ herring are mature. If this analysis corroborates results from this study then the remaining question is where do all the age 2+ herring go or why do age 2+ herring have low vulnerability to the fishery. It should be noted that some members of the Subcommittee disagreed that all (or most) age 2+ herring mature at once, and argued that other species such as salmon mature at different ages and thus, so could herring.

Working Paper Recommendations

1) The Subcommittee accepted the paper with revisions.
2) The Subcommittee agreed with reviewer A who suggested that virtually all age 2+ herring are mature which is strong empirical evidence that something is amiss with the age-structured model. However, the Subcommittee did not feel that the quantitative revisions suggested by Reviewer A were warranted.
3) The Subcommittee also suggested that additional analysis could be completed to address the testing of episodic migrations as a separate paper

P99-3 Pacific herring tagging from 1936 to 1992: a re-evaluation of homing based on additional data

D.E. Hay and P.B. McCarter **Accepted with revisions**

Summary

Federal fisheries agencies in British Columbia started tagging and recovering Pacific herring (*Clupea pallasi*) in 1936. The earliest tagging programs (1936-1967) used

metallic 'belly tags' that were inserted into the body cavity and recovered with magnetic detectors in reduction plants. More recent tagging programs (1979-1991) used plastic 'anchor' tags that were visually detected, usually in fish processing plants but also by fishers and others. There are several previous publications on results of belly tagging programs but the results of the anchor tagging studies have not been fully reported. Recently, the data from both tagging projects, including some unpublished data, were incorporated into a single electronic database. This revised database is relatively large, with about 1.6 million releases and 42,000 recoveries. The new data and new format provides analytical opportunities that were not possible in earlier analyses. This paper presents an analysis of the combined belly and anchor tagging data to comment on the issue of 'homing' in herring. The most recent tagging data, however, is from the most recent anchor tags released in the roe fishery. We use these data, plus the revised belly tagging data and included in the analyses the time at large (time between release and recapture), which was not included in previous analyses. We present analyses that examine apparent 'homing' rates vary as a function of: (1) the types of tag used (anchor versus belly tag) and the fishery and related recovery systems; (2) the season or month of tagging; (3) the period or duration between tag release and tag recapture, in months or years; (4) the geographical size of the area designated as the 'return' area, varying from very small 'Locations' (i.e., < 100 km^2) to very large 'Regions' (i.e., ~10000 km^2). We interpret the results in the context of the current concern about the structure of British Columbia herring populations and make recommendations for future management and research.

Reviewers' Comments

Reviewer A found the paper a useful attempt to draw together a vast amount of herring tag data, and commended the authors for constructing a new data base integrating older and newer data. This reviewer generally agreed with the overall findings and conclusions, and felt the recommendations made were both reasonable and important. However, the reviewer suggested that the title of the paper was not entirely correct, as there does not seem to be as significant an emphasis on "homing" as might be surmised from the title. Rather he concluded that the paper dealt more with the broader question of stock structure and management units, and reaches some interesting conclusions.

Reviewer A recommended additional work in the form of an attempt to estimate a rough spatial scale for herring movements and possible exchanges *versus* number of Sections away from the release location. He concluded the paper leads to a discussion of the appropriateness of present stock and management between spawning areas, but expressed concern that the paper stops short of this discussion. He wondered if the authors had concluded that the present boundaries are appropriate? Finally Reviewer A felt that the suggestion of migrating and non-migrating herring within areas is significant, and that it requires more research.

Reviewer B, on the other hand, was concerned that a lack of specific objectives made the methods and results sections confusing and found serious limitation of the analysis in the understanding of how release/recovery rates vary with the magnitude and location of

herring fisheries. Although the authors recognize this limitation, and propose to include it in future work the reviewer felt it might be quite important to the interpretations presented in this analysis.

Reviewer B thought that the authors could analyse the data more closely to generate an estimate of herring distributions. He disagreed that most herring may not regularly move out of areas defined as regions and concluded that this point required further analysis and substantiation in the results section.

Reviewer B indicated that because of a discussion about the management implications of non-migratory versus migratory herring stocks, the authors should provide specific analysis and examples that address this issue in the results section. He implied that this was an important point, which if substantiated by herring tag data, should be elaborated upon in future research.

This reviewer also felt that the discussion should end with a point summary of major findings. He identified the most important results as: 1) the spatial and temporal scales of analysis influence conclusions regarding homing, 2) there are migratory versus non-migratory herring stocks, 3) DFO regional assessment boundaries are potentially not reflective of the natural distribution of herring.

Subcommittee Discussion

The Subcommittee felt if would be helpful to discuss and emphasize straying. It may be that only the anchor tagging data should be used as these tags were applied relatively close to the spawning grounds.

Fidelity was discussed in terms of fishing locations. Fidelity is defined by the ratio of number of recoveries/total fish tagged in a particular area. This implies the ratio represents the tendency of fish to remain or return to the same place. As described, fidelity is dependent on fishing rates and fishing areas, and this should be emphasised more in the report. The abundance of herring in the area when tags were applied must also be considered. The ratio should be referred to as an "unadjusted ratio" until fishing rates could be worked out. This can be done relatively easily for the anchor tagging but not the belly tagging data.

It was also suggested that for future analysis the log of the returns vs. year at large might be one way to establish total mortality and natural mortality. There has been some work done on sablefish that combines tagging data and catch-at-age-data. This should be evaluated for future analysis.

A good recovery mechanism is a key component of any future tagging program, and therefore programs should be implemented slowly until recovery mechanisms are in place.

Working Paper Recommendations

1) The Subcommittee accepted the working paper subject to revisions
2) The Subcommittee does not recommend any changes to the stock assessment boundaries based on this paper. More work from other studies is required, and therefore it would be premature to adjust any boundaries at this time.
3) Subcommittee also recommended that future tagging programs be of sufficient duration in order to obtain defensible results. It is preferable to have a spatially confined tagging program for a long period of time than it is to have an expansive program for a short duration.

P99-4 Offshore herring distribution and 2000 recruitment forecast for the west coast of Vancouver Island stock assessment region

D. Ware **Accepted with revisions**

Summary

A multispecies mid-water trawl survey off the southwest coast of Vancouver Island (WCVI) was conducted between 11 to 16 August 1999. Twenty-three tows were made to assess the species composition, research vessel catch-per-unit of effort, diet, condition factor, size and age compositions of the dominant pelagic fish species in the WCVI stock assessment region. The offshore distribution of herring was fairly typical this year. The schools were found in their usual concentration centres on 40-mile Bank, Swiftsure Bank and SW Corner. Nine tows targeted on herring. Six tows turned out to be on mixed concentrations of recruit (age 2+) and adult herring, and three were on juvenile schools. Analysis of the length compositions from the adult herring samples suggests that age 2+ recruits will make up about 43 percent of the west coast of Vancouver Island herring spawning stock in March 2000. Based on DFO stock assessment projections of the biomass of surviving repeat spawners (PSARC H99-1), the available biomass of the recruiting 1997 year-class is estimated to be about 6,700 t (95 percent confidence interval of 5,000 to 8,500 t). This places this year-class on the borderline between "poor" and "average" strength. A long-term DFO research program on the west coast of Vancouver indicates that herring recruitment in this region tends to be below average when ocean temperatures are warm, and the summer biomass of migratory predators (primarily hake and mackerel) is high. Water temperatures were extremely high during the first year of life of the 1997 year-class (due to the 1997/98 el Nino). However, the biomass of migratory hake was slightly below average. A retrospective analysis suggests that with this combination of risk factors there is a 60 percent chance that the 1997 year-class will be "poor", and a 40 percent chance that it will be of "average" strength. Hence, both the offshore survey and the risk factor forecast suggest that the 1997 year-class is likely to be between "poor" and "average" in strength. The authors recommend that PSARC Herring Subcommittee use the mean of the "poor" and "average" recruitment projections to estimate the run size and the fishable surplus for the year 2000.

Subcommittee Discussion

The trawl survey carried out to sample offshore herring on the WCVI in 1999 was delayed by the vessel schedule and, as a result, the analysis was not completed in sufficient time to provide for external review. However, the recruitment forecasting methodology employed in 1999 has been reviewed repeatedly in previous years, and found to be sound. In addition, replicate trawl samples were taken on the offshore survey with comparable results. As a result, the Subcommittee supported the forecasting methodology and concurred with the recruitment forecast of poor to average for the WCVI herring stock in 2000.

Working Paper Recommendations

The Subcommittee accepted the working paper, but deferred discussion regarding the recruitment forecast to the section of the meeting in which individual stock forecasts are determined for each stock region.

P99-5 An evaluation of inseason echo sounding estimates of herring biomass
R. Tanasichuk ** Accepted with revisions**

Summary

Peak inseason echosounded biomass was tested as a measure of pre-fishery biomass. Pre-fishery biomass was estimated as the sum of catch, as determined from sales slips, and spawner biomass, as estimated by the escapement stock assessment model. Results of simple linear regression analyses showed there was no relationship between echosounded and pre-fishery biomass estimates. Therefore, inseason echosoundings do not provide any basis for modifying the fishing quota as determined using the current stock assessment methodology.

Reviewers' Comments

Reviewer A felt that the author has made a valuable contribution in raising acoustics as an issue in PSARC herring meetings, since it seems to be successfully applied elsewhere for herring and pelagic species stock assessment. The reviewer agreed that it was a reasonable step to examine the correlation between existing estimates and thought that if the document simply summarised the comparison and stopped, it would stand alone, and the reviewer would limit his comments.

However, the reviewer noted that the author concludes "in-season echosounded biomass cannot be used as a quantitative measure of pre-fishery biomass". He suggested that if the author had simply stated "in-season echo sounded biomass, as it is currently estimated, cannot be used....", it would be acceptable. Moreover, it implies that no acoustic method would work, which is not supported by the present work. This is an important point, since the reviewer believes that the statement unjustifiably discourages

future acoustic work and the reviewer A's interpretation is that the current methodology is unsatisfactory as opposed to showing that acoustics does not work.

Reviewer A concluded that the present methodology cannot be construed as quantitative acoustics and noted that off the shelf hardware and software is now available for real-time biomass estimation of fish abundance aboard commercial fishing vessels. He noted that repeatable, defensible, and cost effective biomass estimates can be generated daily on board commercial fishing vessels probably as fast or faster than by the qualitative methodology described in the Department of Fisheries and Oceans herring sounding manual.

Reviewer B provided some additional comments relating to the purpose of the paper and proposed an alternate title that more explicitly related to the analysis and similar conclusions about modern quantitative acoustic methodologies.

Subcommittee Discussion

Some discussion centred on the scatter plots that the author claimed showed no correlation between soundings and pre-fishery biomass. One of the reviewers pointed out that there is an underlying relationship across all stocks, but it just is not very precise in a particular stock assessment region.

Another topic of discussion was the echo integration used to estimate herring stocks on the East Coast. Apparently, "off the shelf" software is used there to provide rapid estimates of abundance. This was questioned, because the turn around time is thought to be closer to 48 hours. On the west coast, we do not have two days to wait around to set up a fishery. One Subcommittee member noted that the behaviour of herring schools on this coast appears to be different from east coast fish (i.e. much denser, smaller schools).

Finally, there was a question of whether we could try some of the 'off the shelf' software on this coast. Participants questioned what we would do with the information.

Working Paper Recommendations

The Subcommittee accepted the working paper subject to revisions. Revisions should include:

1) The comments about calibrated sounders will be changed to acknowledge that there are many types of sounders used.
2) The sentence about using the same complement of vessels since 1980 will be clarified.
3) The title of the paper should be changed to "A comparison of in-season echo sounding and pre-fishery biomass estimates."

4) The revisions should state what the echo sounding is used as an index of *relative abundance* (i.e. there are lots of herring in Baynes Sound, and none in Lambert Channel).

P99-6 Natural mortality rate of adult herring (*Clupea pallasi*) from southern British Columbia

R. Tanasichuk ** Accepted with revisions**

Summary

Data for over 904,000 Pacific herring (*Clupea pallasi*) seined or gillnetted in British Columbia between 1951 and 1998 was used to estimate age and year specific adult natural mortality rates. Apparent sampling bias precluded using data for all stocks before 1980 and for northern British Columbian stocks since then. The analysis was based on examining the ratio:

$$S_{i,j} = \frac{C_{g,i+1,j+1} + C_{s,i+1,j+1} + A_{i+1,j+1}}{A_{i,j}}$$

where S is the survival rate between spawning seasons, C_g and C_s are the catches at age by gillnets and seines respectively, and A is the spawn survey estimates of spawning escapement. The indices i and j are for age and year respectively.

For the southern (West Coast Vancouver Island, Strait of Georgia) stocks, the instantaneous natural mortality rate is an increasing exponential function of age. Survival rates for Strait of Georgia herring used by the escapement stock assessment model and estimated using the predictive regression for M from age agree well. Surplus energy requirements for gonad recrudescence and overwintering appear to cause the death of adult herring. The author suggests that the sampling bias described in this paper be considered by herring stock assessment models.

The authors' main conclusions were that

1) Biased catch sampling in the north coast, central coast and Queen Charlotte areas resulted in unrealistic survival ratios (greater than 1 in most years). A similar result was noted in the Georgia Strait and West Coast Vancouver Island area in the years before 1980.
2) For the years and areas where sampling appeared to be adequate, it was concluded that the survival ratio, and therefore the natural mortality rate, depended on age, with higher values at older ages.
3) Based on these results, the author recommended that these age-dependent values of M should be used in the assessment.

Reviewers' Comments

Reviewer A generally considered the paper an important contribution to our understanding of natural mortality rates in B.C. herring, and recommended that the paper be accepted with revisions. The reviewer would have preferred a more complete presentation of the recommendations, including quantification of bias in the mortality rates used by both models. Although the paper does mention the possible sources of error, the reviewer felt that a more complete discussion would have been more helpful.

Reviewer A suggested a series of major revisions and a few minor ones. The major revisions suggested related mainly to technical aspects of the analysis. The reviewer felt that the author did not adequately address the issue of uncertainty in the estimated spawning biomass.

There were also some suggestions that related more to how the paper was presented, including bringing a discussion of the expected relationship between mortality and age up to the introduction.

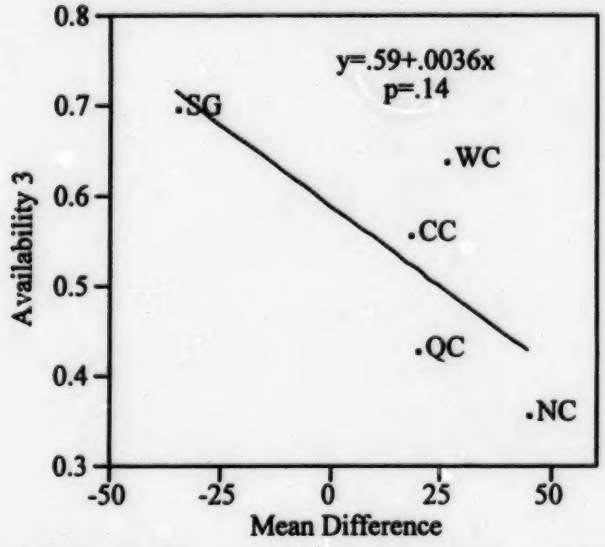
Finally, reviewer A felt that the author overstated some of the points in the last paragraph, notably with respect to the potential differences between northern and southern herring stocks.

Reviewer B stated that this paper provides some insight into the natural mortality rate for herring. Namely, the natural mortality rate varies with age and time. This reviewer agreed with the author that the use of a constant rate of M in fish population models is inappropriate and feels the author presents some valuable background information to set the stage for this study. Reviewer B agreed with the author that M should be calculated directly where data are available and not inferred from life history parameter estimates. This reviewer noted that the author uses the GSI to make inferences about the nature of M. However, reviewer B believes more explanation is warranted for the reader to be able to draw conclusions. The implications for herring stock assessment analysis are not discussed in detail but the author recommends that these results be used for herring population modeling. Before this can be done a more detailed explanation of the data and methods used here is required.

Subcommittee Discussion

One reviewer asked for additional information on the magnitude of the potential bias in assessment results that would stem from using the wrong estimate of natural mortality. It was suggested that this should be examined in the coming year using simulations.

It was also suggested that an experiment be conducted to examine the effect of the timing of catch sampling vs. the time of spawning on the estimates of survival of younger herring. One approach would be to regress the age structured model estimates of age 3 availability as a function of the mean difference between the last day of sampling and first day of spawning, on an area-by-area basis:



Comparison of the mean difference between the last day of catch sampling and the first day of spawning, and the estimated availability of age 3 herring in the 5 herring assessment units (NC = north coast, QC = Queen Charlotte, CC = central coast, SG = Strait of Georgia, WC = west coast Vancouver Island).

Reviewer B suggested that the denominator in the estimate of S should be the total number in year i and age class j. The author responded that the survival rate was measured from the spawning season in year i to the pre-spawning fishery in year i+1. As such, it was appropriate to include the spawning survey as the denominator.

During a general discussion it was noted that the fishery has changed substantially over the time period for which catch and survey data are available. The early years were dominated by reduction fishery that occurred outside the spawning period. This could lead to two problems. The first has to do with association of catches with assessment units. The location of catches was poorly known in those years and the fisheries may have intercepted migrating fish. Secondly, some of the fish caught during the inter-spawning period would have died naturally before the following spawning period. Thus, including all the catch in the numerator of the S ratio would inflate the estimate. It was noted that the catch-age analysis is not sensitive to variations in the timing of the fisheries since it is based on the total catch and the age composition data.

Some of the variability in the survival ratios would also have to do with variation in the spawning survey results. It was suggested that these surveys were more variable in the pre-1980 period than after. It was also noted that the author has assumed that the catchability of the spawning surveys was 1.0. It would be prudent to examine this assumption before drawing firm conclusions.

Working Paper Recommendations

1) The Subcommittee accepted the working paper subject to revisions.
2) The evidence that M increases with age is compelling and the Subcommittee recommends that the implications of this on the results of the catch-age analysis be examined using simulation before the next assessment.
3) The Subcommittee recommended that the results of this evaluation be a guide to how M should be treated in future assessments.

P99-7 An examination of age-specific exploitation of Pacific herring *(Clupea pallasi)* stocks from southern British Columbia by the roe fishery

R. Tanasichuk ** Paper not accepted**

Summary

The author estimated age and year specific gillnet and seine fishing exploitation for the Pacific herring (*Clupea pallasi*) stocks from southern British Columbia (Strait of Georgia, West Coast Vancouver Island). It was found that the proportion of fish by number from the pre-fishery biomass taken by seines was independent of age and was 0.05 ± 0.01 and 0.12 ± 0.02 (mean ± 2 SE) for the Strait of Georgia and West Coast Vancouver Island stocks respectively. The proportion of fish taken by gillnets was affected by age. For both stocks, the proportion the gillnet fishery removed differed among age groupings (2, 3, 4 and 5+). The proportion of ages 2, 3, 4 and 5 and older were 0, 0.01 ± 0.06, 0.06 ± 0.06, 0.21 ± 0.05 for the Strait of Georgia stock and 0, 0.001 ± 0.04, 0.01 ± 0.04, 0.03 ± 0.01 for West Coast Vancouver Island herring. The mean exploitation, weighed by the number of fish in each gillnet grouping, was 0.13 over 1980-98 for both stocks. The author found that the harvest rate, that proportion of biomass removed by fishing, was 0.16 ± 0.03 and 0.14 ± 0.06 (mean ± 2 SE) for Strait of Georgia and West Coast Vancouver Island herring respectively. Neither differed significantly from the harvest rate policy of 0.20.

Reviewers' Comments

Both reviewers found that the paper was in need of significant revisions prior to being accepted. Reviewer A found the paper to be confusing, with an inadequate presentation of data and a hard to follow description of the analysis. Reviewer B indicated that the objective of the paper was poorly stated, and the material in the paper could not support the conclusions arrived at by the author.

Both reviewers noted that the paper was motivated by a concern that size selective gillnet gear removes a higher proportion of older herring. Reviewer A did not understand why exploitation rates were used to examine this issue and reviewer B suggested that the source of the concern should be identified together with some background rationale.

Both reviewers noted concerns with the statistical analysis, with reviewer A suggesting an alternate process to allow a direct comparison of the proportions at age caught by each gear type.

Reviewer B noted that the author confused "high" exploitation rate with "higher" exploitation rate, and also confused harvest rate with exploitation rate.

Finally, reviewer B was critical of the author's choice to include years with no fishery in the analysis.

Subcommittee Discussion

Both reviewers were critical of this paper and did not recommend that it be accepted without major revision. The Subcommittee concurred with the reviewers that the presentation of the data was inadequate, and that the details were not sufficient to allow the analysis to be replicated independently.

Working Paper Recommendations

The Subcommittee decided that the amount of effort required to revise the paper was not warranted at this time, and therefore did not accept the paper. However, the Subcommittee felt that the topic was important and that it could be revisited in the future, following the recommendations and suggestions made by the reviewers.

Fishery Update 1998/1999

A herring fishery update was tabled. This document presented summary information (including tables) on the following herring fisheries: food, social, & ceremonial; roe; spawn on kelp; winter food & bait; special use ZX and ZY; and test. A brief section of stock assessment information, including a spawn area index table and comments on the impact of the dockside roe herring catch validation program on the catch database, is also included in the document.

GENERAL SUBCOMMITTEE RECOMMENDATIONS FOR 1999

The following general recommendations were developed as a result of review of the working papers and Subcommittee discussion:

1. The Subcommittee strongly recommended that a PSARC sponsored workshop be convened in 2000 to examine the Age Structured Model, including the data inputs and parameters used in the model. There would be an opportunity to incorporate other biological information, and to examine alternative model formulations. Procedures for

estimating uncertainty in the spawning biomass should also be discussed and recommendations made.

2. The Subcommittee also recommended that an internal meeting be held as soon as possible to develop a framework for the provision of advice that includes presenting uncertainty in parameters and model structure. The intent would be to rationalise the relationship between the different forecasting models and identify a mechanism for quantifying the level of uncertainty contained in the advice.

3. Continue the work initiated as a result of the recommendation in the 1998 report which identified that since annual recruitment contributes a large component (30% to 50%) to the herring spawning biomass, it is important to have an increased understanding of herring recruitment as the key to determining the productivity of stocks and to identifying harvest opportunities. The Subcommittee recommended that offshore recruitment forecasting work for the west coast Vancouver Island herring stock continue, and that the potential for recruitment forecasting for other major stocks continue to be investigated.

4. The Subcommittee recommended that the analysis of juvenile survey data in the Strait of Georgia be repeated for the 1996 and 1997 surveys after these year classes have recruited in year 2000.

5. It was noted that stock identification is a key biological question and that work initiated in 1999 should be continued in 2000.

6. There are emerging hydroacoustic techniques and technologies that may have some merit in Pacific herring management, and therefore the Subcommittee recommended that these be investigated.

7. The Subcommittee again recommended that the analysis of variability in spawn timing and location be extended to assess the possible influence of fishing effects.

8. The Subcommittee reiterated the importance of conducting spawn surveys outside the major stock assessment regions.

9. The Subcommittee noted the need for more complete Food, Social and Ceremonial catch data.

10. In response to a concern about the impact of fishing related mortalities, it was recommended that a literature review of the impact of gillnet drop out and potential sub-lethal mortalities be conducted for presentation at the 2000 meeting.

PROGRESS ON SUBCOMMITTEE RECOMMENDATIONS FOR 1998

Subcommittee recommendations from 1998 are listed below (*Italics*) along with progress reported at the meeting:

1. *The Subcommittee strongly recommended that the assumptions underlying the age-structured model should be closely examined. In particular, the Subcommittee recommended:*

   (a) that the catchability and M parameters be fixed to constant values to determine the effects on the ASM output (note that an addendum was presented to the Subcommittee on September 3, 1998 which addressed this issue in part);
   (b) that the proportionality of the ASM tuning index to herring stock biomass be validated by comparison with a virtual population analysis (VPA);
   (c) that the relationship of the natural mortality parameter to other ASM parameters be investigated in light of the high variation in estimates of natural mortality (0.27 in the Central Coast to 0.59 in the Strait of Georgia);
   (d) that the hypotheses of stock migration and temporal change in maturity schedules be investigated to determine their consistency with the available data.

Progress has been made, but there is still work to be done in this area. The workshop referred to in recommendation 1 (above) will continue this work.

2. *Since stock reconstruction models (i.e. catch-at-age models) may not provide optimal forecasting precision, the Subcommittee recommended that work be initiated on a statistical forecasting model to determine whether forecast performance can be improved.*

Work is planned to begin in November.

3. *The Subcommittee recommended a review of criteria for assessment of stock status prior to the 1999 PSARC meeting. The Subcommittee concluded that critical review is required for (1) the selection of the recruitment scenario, and (2) the practice of averaging forecasts from the ASM and EM. The Subcommittee supported work to guide choices among candidate assessment models and to better communicate uncertainty in stock status to managers and stakeholders.*

The Subcommittee considered some options, but more investigation is required to present uncertainty.

4. *Since the spawn index is critically important to the generation of scientific advice on herring resource status, there is a need to critically evaluate the consistency of the information over time and to identify the impact of changing survey methodology. The Subcommittee confirmed its support for the development of empirical estimates of variability for the spawn index. These estimates are essential to fully understand the uncertainty in biomass estimates and stock forecasts. The Subcommittee noted that this analysis would require collaborative input from Science and Management staff.*

No progress was made in the quest to derive estimates of uncertainty around the spawn index.

5. *Given the decline in size-at-age described in Working Paper H98-3, the Subcommittee recommended that the most recent size-at-age information (the 1998 samples) be used in the computation of biomass forecasts pending the development of trend projections. This recommendation is reflected in the stock forecasts for 1999.*

This was done for the 1999 and 2000 forecasts.

6. *Annual recruitment contributes a large component (30% to 50%) to the herring spawning biomass. Thus, increased understanding of herring recruitment is key to determining the productivity of stocks and to identifying harvest opportunities. The Subcommittee recommended that offshore recruitment forecasting work for the west coast Vancouver Island herring stock continue, and that the potential for recruitment forecasting for other major stocks be investigated.*

The WCVI recruit work has been done, including a new neural network modelling method which has been peer reviewed and accepted for publication. The technique has been investigated for other areas, but further work is required. (refer to recommendation 3 above)

7. *The Subcommittee recommended reviewing the Cutoff of 17,600 tonnes for the Central Coast assessment region. Although the Cutoff was examined in H98-1, the Subcommittee elected to reassess the Cutoff pending the results of diagnostic tests to validate the ASM.*

As noted, there is additional work required on the Age Structured Model, and a workshop has been recommended to pursue this.

8. *Work to diagnose the poor performance of the age-structured model in the Prince Rupert District was conducted in 1998 (see H98-1), but has not fully resolved the discrepancy with the escapement model estimates. Pending the results of diagnostic work on the ASM, the Subcommittee recommended continued efforts to identify the cause(s) of the difference and to rationalise the model predictions, if possible. This work should include a retrospective analysis of the escapement model performance.*

No retrospective analysis of the escapement model performance was conducted in 1999.

9. *The Subcommittee recommended that the analysis of variability in spawn timing and location be extended to assess the likely influence of fishing effects.*

Work is ongoing.

10. *The Subcommittee recommended that the analysis of juvenile survey data in the Strait of Georgia be repeated for the 1996 and 1997 surveys after these year classes have recruited in year 2000.*

Work has been rolled over. (recommendation 4 above)

PARTNERSHIPS WITH CLIENTS

In 1995, a meeting was convened with client groups immediately following the PSARC review of herring stock assessments. This meeting, termed a "Biological Review", had the objective of fostering improved partnerships with client groups which had expressed displeasure with being excluded from the PSARC process. Science Branch staff presented herring stock assessments and forecasts for the subsequent year; discussion was confined to the biological basis for these assessments. Unfortunately, the meeting was not well attended by clients in 1995. As a result, the Biological Review was not held in 1996. Prior to the 1997 fishery, managers met with interested processors, fishers, First Nations organizations, and Provincial staff to present assessment and management information. External participants from industry and First Nations attended the PSARC Herring meeting in 1997 to assist in reviewing the assessment documents. In 1998, the review process was further expanded to include participants from seven First Nations, four industry participants, a B.C. Ministry of Fisheries participant, and DFO assessment experts from outside the Pacific Region. At the 1999 PSARC Subcommittee meeting, there were five First Nations participants, two industry participants and one participant from Parks Canada.

Stock status reports have been completed for each of the five major herring stocks and will be updated to reflect the 1999 fishery and assessment. The Subcommittee continues to consider innovative strategies, such as video taped reviews for cable television, to disseminate information to the general public.

Appendix 1 PSARC Pelagic Subcommittee Meeting Agenda, August 31-September 2, 1999

PSARC Pelagic Subcommittee Agenda	**August 31, September 1 & 2, 1999 8:30 AM to 4:30 PM Best Western Bayside Inn Tidal Room Parksville, B.C.**	
Tuesday, August 31, 1999		
Introductions and Review of Agenda	D. Radford	8:30-9:00
-Purpose of meeting and outline of Process		
-Assignment of Rapporteurs		
1. Review of Background Information		
Mortality rates		
P99-6: Natural mortality rate of adult herring (*Clupea pallasi*) from southern British Columbia	R. Tanasichuk	9:00-10:00
• Break		10:00-10:15
P99-7: An examination of age-specific exploitation of Pacific herring (*Clupea pallasi*) stocks from southern British Columbia by the roe fishery.	R. Tanasichuk	10:15-11:00
Stock structure		
P99-3: Pacific herring tagging from 1936 to 1992: a re-evaluation of homing based on additional data	D. Hay	11:00-12:00
• Lunch		12:00-13:00
Recruitment/maturation		
P99-2: Age of sexual maturation and recruitment in Pacific herring	D. Hay	13:00-14:00
P99-4: Offshore herring distribution and 2000 recruitment forecast for the west coast of Vancouver Island assessment region	D. Ware	14:00-15:00
• Break		15:00-15:15
Echosounding		
P99-5: An evaluation of inseason echo sounding estimates of herring biomass	R. Tanasichuk	15:15-16:30

Wednesday, September 1		
Fishery Update	L. Hamer	8:30 - 8:40
Fishery update 1998/99		
2. Review of 1999 Assessment and Stock Status Reports		
P99-1: Stock assessment for British Columbia herring in 1999 and forecasts of the potential catch in 2000	J. Schweigert	8:40 – 15:00
• Break		10:00-10:15
• Lunch		12:00-13:00
• Break		15:00-15:15
Review and Finalization of Rapporteur's Reports from Day 1		15:15-16:30
Thursday, September 2		
3. Formulation of Advice and Recommendations		8:30-10:00
• Break		10:00-10:15
Review and Finalization of Rapporteur's Reports from Day 2		10:15-12:00
• Lunch		12:00-13:00
4. Concluding comments		13:00-13:15
5. Planning for next meeting		13:15-14:45
6. Adjourn		15:00

Appendix 2 PSARC Pelagic Working Papers for 1999

No.	Title	Authors
P99-1	Stock assessment for British Columbia herring in 1999 and forecasts of the potential catch in 2000	J. Schweigert C. Fort
P99-2	Age of sexual maturation and recruitment in Pacific herring	D. Hay P. McCarter
P99-3	Pacific herring tagging from 1936 to 1992: a re-evaluation of homing based on additional data	D. Hay P. McCarter
P99-4	Offshore herring distribution and 2000 recruitment forecast for the west coast of Vancouver Island assessment region	D. Ware
P99-5	An evaluation of inseason echo sounding estimates of herring biomass	R. Tanasichuk
P99-6	Natural mortality rate of adult herring (*Clupea pallasi*) from southern British Columbia	R. Tanasichuk
P99-7	An examination of age-specific exploitation of Pacific herring (*Clupea pallasi*) stocks from southern British Columbia by the roe fishery	R. Tanasichuk

List of Reviewers

Name	Association
Carolsfeld, Y.	World Fisheries Trust, Vancouver
Clark, B.	International Halibut Commission, Seattle
Fargo, J.	DFO, Pacific Biological Station
Holtby, B.	DFO, Pacific Biological Station
Kieser, R.	DFO, Pacific Biological Station
Kronlund, R.	DFO, Pacific Biological Station
Perry, I.	DFO, Pacific Biological Station
Robinson, C.	Parks Canada, Vancouver
Stanley, R.	DFO, Pacific Biological Station
Ware, D.	DFO, Pacific Biological Station
Wood, C.	DFO, Pacific Biological Station

Appendix 3 List of Participants for August 31-September 2, 1999 PSARC Pelagic Meeting

Name	Association
Braniuk, R.	DFO, South Coast Division
Chalmers, D.*	DFO, South Coast Division
Fort, C.*	DFO, Pacific Biological Station
Gordon, L.*	DFO, Port Alberni
Greba, L.	Kitasoo Band Council
Hall, D.	Nuu-chah-nulth Tribal Council
Hamer, L.*	DFO, South Coast Division
Hay, D.*	DFO, Pacific Biological Station
Hill, B.	Tsimshian Nation
Jones, R.	Council of Haida Nations
Kadowaki, R.	DFO, Pacific Biological Station
McCarter, B.*	DFO, Pacific Biological Station
McPhee, B.	Heiltsuk Tribal Council
Midgley, P.*	DFO, South Coast Division
Radford, D.* (Subcommittee Chair)	DFO, Regional Headquarters
Robinson, C.	Parks Canada
Safarik, E.	Herring Conservation Resource Society
Schweigert, J.*	DFO, Pacific Biological Station
Sinclair, A.	DFO, Pacific Biological Station
Stocker, M. (PSARC Chair)	DFO, Pacific Biological Station
Tanasichuk, R.*	DFO, Pacific Biological Station
Thomas, G.*	DFO, South Coast Division
Ware, D.*	DFO, Pacific Biological Station
Wilson, B.	Aboriginal Vessel Owners of B.C.

* Subcommittee Members

Appendix 4 Criteria for assessment of stock status in 1999: Queen Charlotte Islands

	Criteria	Status
1	Data quality:	
	(a) all catch reported	Incomplete FSC catch, est. by fishery manager at 5000lb.
	(b) all spawn surveyed	Generally complete, Eggar's Bay not surveyed due to SOK, some light patches not surveyed.
	(c) good sample coverage	Yes, samples from all fisheries.
2	Stock status and trends:	
	(a) Age-structured model	Biomass increasing
	(b) Escapement model	Biomass one-third less than 1998
	(c) Spawn indices	Spawn length and width down from 1998
3	Perception of stock status:	
	(a) charter skippers comments	Stocks adequate to good, soundings may be conservative, peak of 9500 tons.
	(b) Management staff	
4	Recruitment:	
	(a) age-structured model	94 and 95 year-classes good, 96 year-class poor.
5	Retrospective Analysis	
	(a) Consistency	Good, slight tendency to over forecast biomass.
6	Forecast Abundance	
	(a) Profile Likelihood	95% probability that biomass will be greater than 28,900 tonnes.
	Recruitment assumption:	Escapement Model
	• Poor	• 13,060
	• **Average**	• **15,080**
	• Good	• 20,440
7	Additional information	
	(a) Size-at-age	Slight increase from 1998.
8	Cutoff	10,700
	Yield Recommendation	Based on the ESM forecasts assuming an average recruitment a harvestable surplus of 3020 tonnes was accepted.

Appendix 5 Criteria for assessment of stock status in 1999: Prince Rupert District

Criteria	Status
1. Data quality:	
(a) All catch reported	No FSC catch reported.
(b) All spawn surveyed	Some of the Big Bay spawn hatched prior to survey.
(c) Sampling coverage	Good coverage of areas 4 and 5.
2. Stock status and trends:	
(a) Age-structured model	Biomass increase over 1998.
(b) Escapement model	Biomass increase over 1998.
(c) Spawn Indices	Spawn length increased considerably, but width declined.
3. Perception of stock status:	
(a) Charter skippers comments	Improvement in stock status. 18,000 tons sounded in Big Bay and 10,000 tons sounded in Kitkatla.
(b) Management staff	Shift in spawn pattern. More spawning in Venn Passage area.
4. Recruitment:	
(a) Age-structured model	Good 1994 and 1995 year-classes, poor 1996 year-class.
5. Retrospective Analysis	
(a) Consistency	No longterm consistency in the ASM retrospective pattern of abundance.
6. Forecast Abundance	
(a) Profile Likelihood	Biomass forecast for ASM has 95% probability of exceeding 30,700 tonnes.
Recruitment assumption:	Escapement Model
• Poor	• 33,560
• **Average**	• **37,000**
• Good	• 47,510
7. Additional information	
(a) Size-at-age	Increase over 1998.
8. Cutoff	12,100 tonnes
9. Yield Recommendation	Based on the ESM forecasts assuming an average recruitment a harvestable surplus of 7,400 tonnes was accepted.

Appendix 6 Criteria for assessment of stock status in 1999: Central Coast

	Criteria	Status
1.	Data quality:	
	(a) All catch reported	No FSC catch reported.
	(b) All spawn surveyed	Complete surveys of areas 7-10.
	(c) Sampling coverage	Good coverage of all fisheries.
2.	Stock status and trends:	
	(a) Age-structured model	Similar to 1998.
	(b) Escapement model	Similar to 1998.
	(c) Spawn Indices	Length and width similar to 1998.
3.	Perception of stock status:	
	(a) Charter skippers comments	Shift of fish south, increase in biomass in southern areas such as Stryker Bay.
	(b) Management staff	Shift in spawn to areas outside of the usual seine areas.
4.	Recruitment:	
	(a) Age-structured model	Good 1994 and 1995 year-classes, poor 1996 year-class.
5.	Retrospective Analysis	
	(a) Consistency	Consistent ASM retrospective pattern with slight tendency to overforecast.
6.	Forecast Abundance	
	(a) Profile Likelihood	ASM projects a 95% probability that biomass will exceed 25,166 tonnes.
	Recruitment assumption:	Escapement Model
	• Poor	• 43,940
	• **Average**	• **47,040**
	• Good	• 58,430
7.	Additional information	
	(a) Size-at-age	Increase from 1998.
8.	Cutoff	17,600 tonnes
9.	Yield Recommendation	Based on the ESM forecasts assuming an average recruitment a harvestable surplus of 9,410 tonnes was accepted.

Appendix 7 Criteria for assessment of stock status in 1999: Strait of Georgia

	Criteria	Status
1.	Data quality:	
	(a) All catch reported	All catch reported.
	(b) All spawn surveyed	Early spawn in Nanoose Bay not surveyed, all major spawns covered but concern that spawns are concentrated in Area 14.
	(c) Sampling coverage	Complete except for areas 13 and 15.
2.	Stock status and trends:	
	(a) Age-structured model	Slight decrease from 1998.
	(b) Escapement model	Similar to 1998.
	(c) Spawn Indices	Length decreased slightly and width increased slightly.
3.	Perception of stock status:	
	(a) Charter skippers comments	60-70,000 tons sounded, a slight decrease from 1998. Weather made sounding difficult.
	(b) Management staff	Spawn abundance similar to 1998.
4.	Recruitment:	
	(a) Age-structured model	1996 year-class was between poor and average.
5.	Retrospective Analysis	
	(a) Consistency	Reasonably consistent but a tendency to underforecast abundance with ASM.
6.	Forecast Abundance	
	(a) Profile Likelihood	ASM model projects a 95% probability that biomass will exceed 41,383 tonnes.
	Recruitment assumption:	Escapement Model
	• Poor	• 68,180
	• **Average**	• **84,720**
	• Good	• 106,810
7.	Additional information	
	(a) Size-at-age	Increased from 1998.
8.	Cutoff	21,200 tonnes
9.	Yield Recommendation	Based on the ESM forecasts assuming an average recruitment a harvestable surplus of 16,940 tonnes was accepted.

Appendix 8 Criteria for assessment of stock status in 1999: W.C Vancouver Island.

	Criteria	Status
1.	Data quality:	
	(a) All catch reported	FSC catch is incomplete.
	(b) All spawn surveyed	Barkley Sound deep spawnings incompletely surveyed, Hesquiat Harbour spawns incomplete, Area 25 survey good.
	(c) Sampling coverage	Good in Areas 23 and 25, Area 24 samples lost.
2.	Stock status and trends:	
	(a) Age-structured model	Decrease from 1998.
	(b) Escapement model	Decrease from 1998.
	(c) Spawn Indices	Spawn length increased, spawn width, layers, and percent cover decreased.
3.	Perception of stock status:	
	(a) Charter skippers comments	Hot Springs Cove and Friendly Cove had good spawnings.
	(b) Management staff	20,000 tons sounded in Barkley Sound but difficult to assess due to weather.
4.	Recruitment:	
	(a) Age-structured model	Good 1994 year-class, 1995 and 1996 year-classes poor.
5.	Retrospective Analysis	
	(a) Consistency	Generally consistent, ASM has slight tendency to underforecast. Overforecast in 1998.
6.	Forecast Abundance	
	(a) Profile Likelihood	ASM indicates a 95% probability that biomass will exceed 13,065 tonnes.
	Recruitment assumption:	Age-structured Model
	• Poor	• 19,230
	• **Poor-Average**	• **21,500**
	• Average	• 23,760
	• Good	• 38,320
7.	Additional information	
	(a) Size-at-age	
8.	Cutoff	18,800 tonnes
9.	Yield Recommendation	Based on the ASM forecasts assuming a poor-average recruitment, a harvestable surplus of 2,700 tonnes was accepted (21,500 – Cutoff = 2,700).